

THOMPSON IMPROVED INDICATOR



MANUFACTURED ONLY BY

American Steam Gauge Co.,

34, 36 & 38 CHARDON STREET,

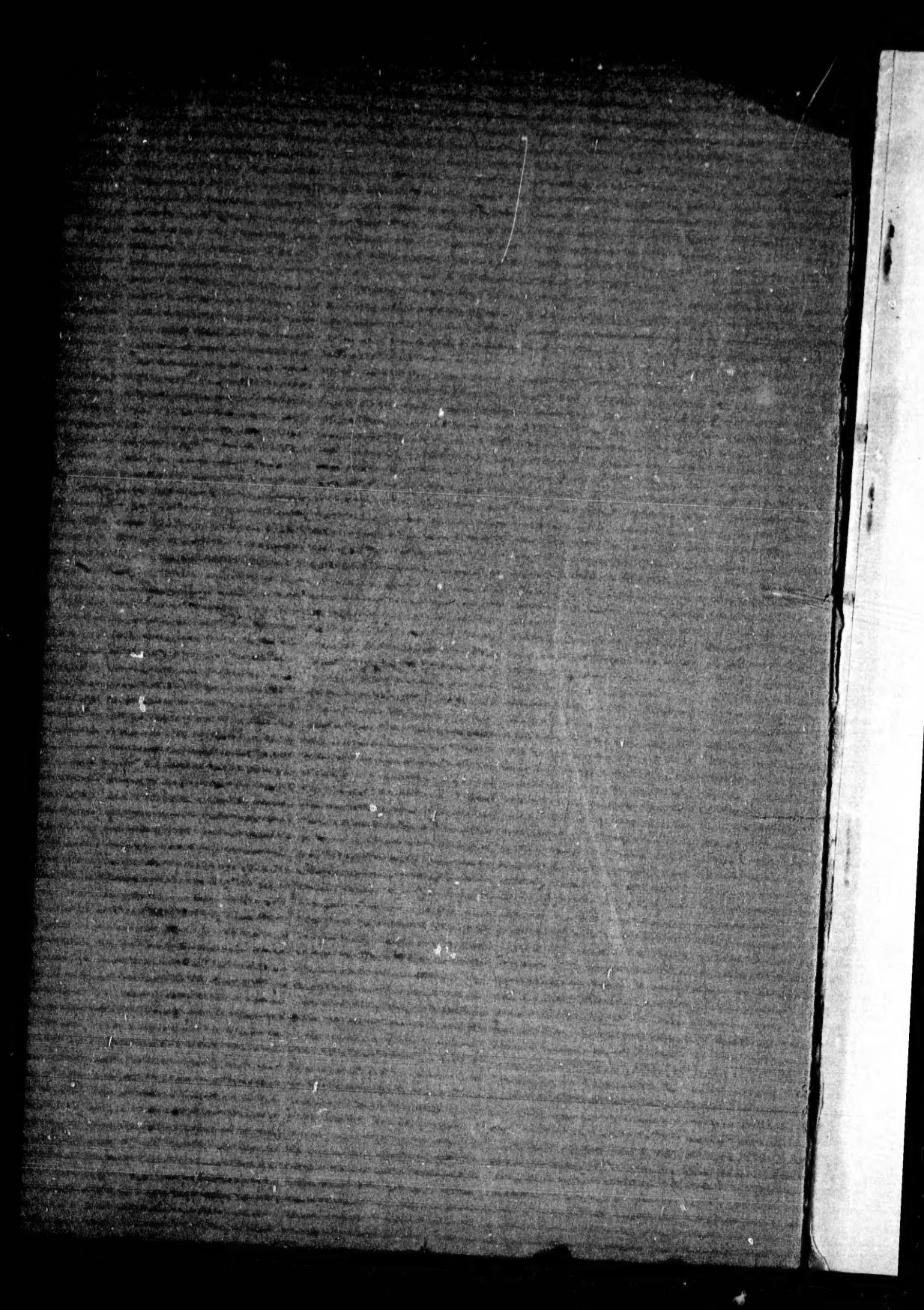
BOSTON, MASS.

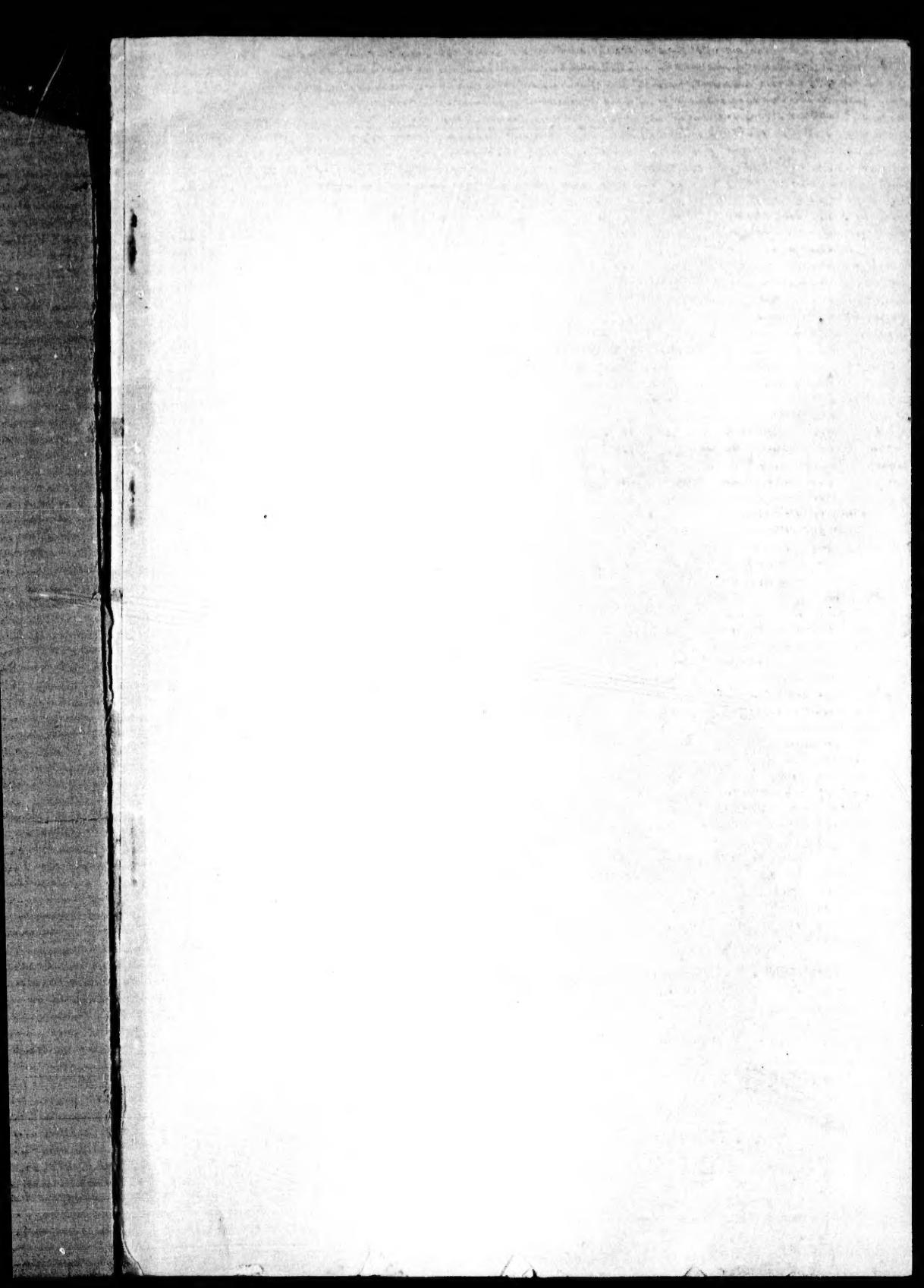
New York Branch:

51 JOHN STREET, NEW YORK.

Western Branch:

16 NORTH CANAL STREET, CHICAGO, ILL.





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BUSINESS ESTABLISHED IN 1851.

INCORPORATED IN 1854.

(ORIGINAL STEAM GAUGE COMPANY.)

AMERICAN STEAM GAUGE COMPANY,

SOLE MANUFACTURERS OF THE

BOURDON STEAM GAUGE,

WITH LANE'S IMPROVEMENT.

THOMPSON'S & RICHARDS' STEAM-ENGINE INDICATORS, AMSLER'S POLAR PLANI-METER, THE PANTOGRAPH, HUSSEY'S SPEED INDICATOR, AMERICAN POP SAFETY VALVES.

ALSO

Water Gauges, Gauge Cocks, Whistles, Revolution Counters, Seth Thomas and Howard Clocks, Pyrometers, Hydrometers Salinometers, Spring Balances, Mercurial Ciphot Gauges, Low Water and Alarm Gauges, and all kinds of Steamship Instruments.

34, 36 & 38 CHARDON STREET,
BOSTON, MASS.

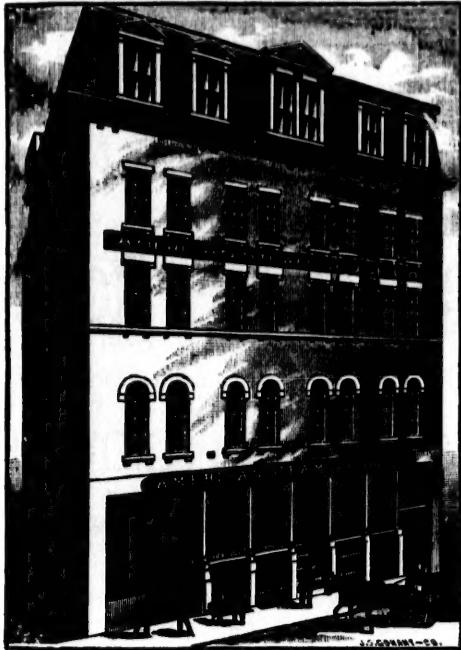
NEW YORK BRANCH,

51 JOHN STREET, NEW YORK.

WESTERN BRANCH,

16 N. CANAL ST., CHICAGO, ILL.

American Steam Gauge Co., Boston.



OFFICE AND MANUFACTORY OF

American Steam Gauge Co.

Nos. 34, 36 & 38 CHARDON STREET,

BOSTON, MASS.

New York Branch, 51 JOHN ST., NEW YORK.

Western Branch, 16 No. CANAL ST., CHICAGO, ILL.

American Steam Gauge Co., Boston.

THE THOMPSON IMPROVED INDICATOR.

THE ONLY PERFECT INDICATOR MADE.

PATENTED AUGUST 31, 1875, JULY 12, 1881, AND JUNE 26, 1883.

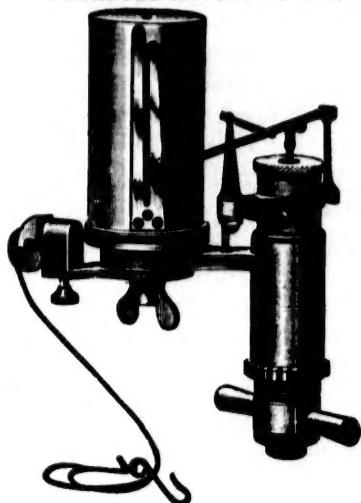


Fig. 1.—Outside.

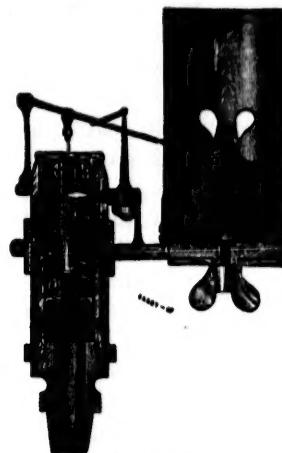


Fig. 2.—Inside.

The Thompson Improved Indicator was patented by J. W. Thompson, Aug. 31, 1875 and July 12, 1881; and by careful consideration of the demands of the engineering public, we have from time to time improved it, and it is now conceded by all prominent engineers to be the standard steam-engine indicator for the U.S. and all foreign countries.

The radical improvements, as made in the old-style Thompson Indicator, consists of lightening the moving parts, substituting steel screws in place of taper pins, using a very light steel link instead of a large brass one, reducing the weight of the pencil lever, also weight of squares on trunk of piston, and lock-nut on end of spindle, and increasing the bearing on connection of parallel motion. By shortening the length, and reducing the actual weight of the paper cylinder just one half, and by shortening the bearing on spindle, also lowering the spring casing to a nearer plane to that in which the cord runs, we have reduced the momentum of the paper cylinder to a very small amount. All of these improvements have lessened the amount of friction, which was heretofore very small, but is now reduced to a minimum; and, furthermore, they

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tend to improve, on the whole, an instrument whose principle has always been of undoubted correctness.

In calling attention to the features of this instrument, we prefer to do so subject to all amenities of business courtesy, leaving our products to speak for themselves, and others to do the same; but, in justice to ourselves and our instrument, we shall not allow to pass certain representations published by the makers of rival instruments.

In the pamphlet issued in behalf of the Tabor Indicator certain statements are made as showing the relative performances and relative weights of moving parts of both instruments. To these statements we will simply state, the matter of relative performances was not done as a public test, and cannot be taken as a basis of comparison. The table of comparative weights was deducted by comparison with the old-style Thompson Indicator, and should not be considered any comparison with the Thompson Improved Indicator as now made.

In the circular issued by the makers of the Crosby Indicator, certain statements are made, and diagrams shown, tending to depreciate the efficiency of the paper-cylinder spring of the Thompson Indicator.

The machine used to produce the diagrams referred to is one of very questionable correctness, and, wherever used in public, has left an uncertainty, amounting, in fact, to a doubt.

The conditions of a test conducted in private can never be considered fair representations of the competing instruments; and, to determine to the satisfaction of all parties interested, *we herewith challenge the makers of all other indicators to an open and public test, to determine the efficiency of the different instruments.*

In the Crosby Indicator, the paper drum spring is a spiral spring; the advantages claimed for same over the coil spring, producing, briefly stated, a "uniform stress on the cord" throughout the stroke.

In order to have this, the force of the spring should be least when the inertia of the drum has to be overcome by the cord in opposition to the force of the spring, and greatest when the inertia is to be overcome by the spring.

But, admitting that it is possible to secure nearly uniform stress on the cord in a given case, it will be evident, that, to secure that

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result, there must be perfect co-operation amongst all of the following factors :—

1. The speed of the engine.
2. The length of the diagram.
3. The tension of the spring.
4. The length of the spring.
5. The weight of the drum.

It is evident that but two of these factors can be secured in the construction of the instrument; namely, the fourth and fifth: and these being once adapted to a given speed, the instrument cannot be adapted to any other speed, except to the very limited extent allowed by variations of the tension of the spring or in the length of the diagram.

The difference required for different speeds would, other things equal be different lengths of spring; the slower speeds requiring the longer springs in inverse proportion to the number of revolutions per minute. Thus, an instrument being properly adjusted for a speed of 300 revolutions, would require a spring twenty-five times longer for a speed of 60, that being the square of the ratio of the two speeds, 5 to 1.

Also, if applied to the latter speed as adapted to the higher speed, the stress on the cord would vary nearly as much as the force of the spring; and the resulting diagram would be as much shorter than the movement of the reducing-gear from which it was derived, as the cord would vary in stretch.

In point of fact, all springs, "volute" and "spiral," alike possess the property required for the theory for all increase in resistance as the cord is drawn; and every one is adapted to some speed, though some speeds met with are so slow as to require a spring of more uniform resistance than could be introduced in either form, particularly in the spiral form.

From the foregoing, it will be seen that it is utterly impossible to have uniform stress on the cord, except at or near the speed for which the spring is adapted.

Furthermore, in increasing the tension of the spiral spring, the spring is twisted and distorted, thereby binding and throwing it out of position, necessarily causing rough and uneven motion of the whole drum movement.

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The foregoing facts are not submitted to depreciate the instrument named, but are simply offered in self-defence.

FEATURES OF THE THOMPSON IMPROVED INDICATOR.

Parallel Motion.

The Parallel motion of the Thompson Improved Indicator is the most accurate of anything used or ever seen in the indicator line, and errors said to exist in drawing correct vertical lines do not appear in the limited movement of the pencil in taking diagrams from a steam-engine.

The parallel movement of the pencil is secured by a link attached to and governing the lever direct. The pivots of this link are made free from any appreciable lost motion, and will remain so indefinitely; but, if any such lost motion should exist, it will affect the integrity of the parallel movement only to an extent equal to it, *not three or four times that amount*. The parallel movement will be affected only by the play in the pivots of the link, and not in any degree or manner by the play of any other parts. When the parallel movement is affected by controlling the connecting-rod, either by a curved slot in it and a guiding roller, or by attaching the link to it, *as in other instruments*, it (the parallel motion) becomes dependent for its accuracy on the fit of several parts, play in any one of which will cause an uncertainty and possible inaccuracy in the parallel movement equal to three or four times the amount of such play.

The force required to guide the lever in its parallel movement is received on the pivots of the link alone, where the friction it causes is practically inappreciable.

With the slot and roller device, this guiding-force is received on several rapidly moving surfaces, multiplied in amount by leverage. The same is true to a considerable extent of the plan of attaching the link to the connecting-rod.

The Paper-Cylinder Movement.

It is so constructed that the tension of the coiled drum spring within the paper cylinder can be increased or decreased, for different

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speeds of engines. As little or as much of the spring can be taken up or let out as desired, thereby providing for fine adjustments, and not, as in other instruments, where a whole coil must be taken up, or none.

For high speeds, our instrument will give accurate results for all practical purposes, without any special adjustments further than to give sufficient tension to keep the cord taut at all points.

When exceptionally accurate work is desired, the length of the diagram may be carefully measured, and compared with the length of a line traced on the paper when the engine is moved slowly. If the diagram is found to differ in length from this line, vary the tension of the spring till they agree. The paper cylinder, or "drum," we now make with covered top.

Levelling Pulley for Paper Cylinder.

This latest improvement in the Thompson Improved Indicator was patented June 26, 1883, and consists (see Fig. 1) of a wheel which leads the cord through the hole, in contact with the scored wheel, over which the cord can be run to any possible angle, to connect with the motion, wherever it may be, or of whatever kind.

The pulley works in a sleeve which rotates in the stand according to the adjustments required, and which is held in its position, where adjusted by the thumb screw, which acts as a binding-screw working in the groove on the sleeve. By this it is held in any position that may be chosen, and yet be free to revolve the moment the binding-screw is loosened, without any possibility of interfering with the motion by means of scarring the sleeve, or disturbing the particles of metal on surface. It also gives all the desired freedom of motion and facility of adjustment.

By means of the set screw, the stand which carries the wheel can be adjusted to run the cord to any possible angle within a range of three hundred and sixty degrees.

In the double pulley arrangement, as used in other indicators, the range of adjustment is limited; and in some cases the cord cannot be made to run in a number of certain directions without having it run grating, rough and uneven.

In this improved swivel pulley, the use of carrying-pulleys is done away with, and from the fact, that, no matter what the angle

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of deflection may be, or what direction it may be necessary to take the cord, it will work smoothly; for the pulley face and the face of the groove on the paper cylinder are always in the proper position, one with the other, to take the cord to the motion, wherever that may be arranged.

In high-speed short-stroke electric-light engines, great range of adjustment is very important; for considerable trouble is experienced sometimes, upon engines running three hundred and fifty and three hundred and sixty revolutions per minute, in so arranging the cords, as to use independent arcs, or making such connections with reference to right lines that no distortion of diagram should be given.

We are the sole owners of the swivel pulley, having purchased the United States patent from the patentee; and we hereby caution all parties against purchasing any other indicator having this device, as we shall hold them responsible, as well as the manufacturer.

Stop Motion.

It is provided with a "stop motion" (see Fig. 3) which is so arranged that the horn-handle screw can be screwed up against the

post or stop placed midway between paper cylinder and steam cylinder so as to regulate the pressure of pencil lead upon the paper.

Springs.

The best and finest quality of steel wire is used in making our springs; and they are all wound on a mandrel, and tempered in the most careful manner by the oldest and most experienced workmen in the business.

All our springs are wound on mandrels from four to four and one-half threads to the inch, and thereby give more wire to each spring, and a consequent

less strain, than if wound, as in springs of other indicators, on mandrels two to three threads to the inch.

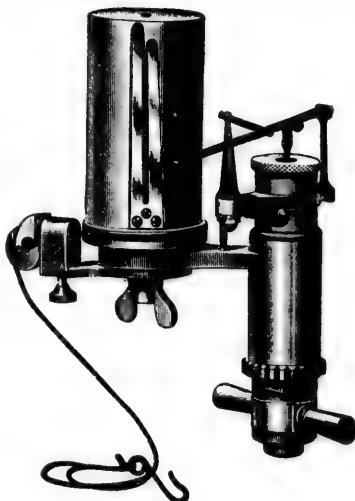


Fig. 3.

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Whatever grinding is done to lighten a spring, amounts to very little; in fact, at the most, it is never ground to cause more than one to three pounds difference in one hundred pounds; and, when the sensitiveness of our springs is considered, very little grinding will produce this result.

All springs used in other instruments, whether double, single, or having a steel bead for bottom end, when connected, and under steam pressure, do not possess the freedom of movement claimed, but are, in fact, as rigid as those made with double heads, like ours.

All springs we make are scaled, providing for vacuum; and the capacity of any spring can be ascertained by the following general rule: Multiply scale of spring by $2\frac{1}{2}$, and subtract 15, and the result will be the limit of pounds steam pressure to which spring should be subjected. Example: 40-pound spring $\times 2\frac{1}{2} = 100 - 15 = 85$ pounds pressure, capacity of a 40-pound spring.

To adapt the Thompson Improved Indicator to all pressures, we make springs to any desired scale. The following are the most generally used: 8, 10, 12, 16, 20, 24, 30, 32, 40, 48, 50, 56, 60, 64, 80, 100. For pressures from 65 to 85 pounds, a 40-pound spring is best adapted; for, as 40 pounds pressure on a 40-pound spring will raise pencil one inch, 80 pounds pressure on the same spring will raise pencil about two inches, which is the usual height of a diagram.

Vacuum Springs.

All our springs are scaled providing for vacuum, but close experiments have shown us that from the fact that springs compress and elongate in unlike proportions, the regular pressure springs vary about one pound in fifteen, or about $6\frac{1}{2}$ per cent.

We make a special vacuum spring, regular thread, scaled for vacuum only, which we furnish at the regular price for pressure spring, \$5.00 each.

All of our springs are subjected to a severe test before leaving the factory, and they will always be found accurate in actual use.

To Change Springs.

First, unscrew the milled nut at the top of steam cylinder; then take out piston, with arm and connections; disconnect pencil lever and piston by unscrewing the small knurled-headed screw which connects them; remove the spring from the piston, substitute desired one, and put together in same manner, being careful, of course, to

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screw the spring up against shoulder, and down full to the piston head. This arrangement for changing springs is simple, easy, and convenient, and does not require the use of any wrench or pin of any kind.

To change springs in all other instruments, either a pin or a wrench must be inserted between the coils of the spring, disconnecting the piston. By reason of the form of the coils, not over $\frac{1}{16}$ of an inch throw can be got by the pin or wrench at one time. When the piston is hot, the trouble attending such an operation can be imagined. Furthermore, in the Thompson Improved Indicator, the ball and socket joint is adjusted to scale with each spring a complete vacuum, or its equivalent, 14.7 pounds; and this adjustment need never be changed: but in other instruments, every time a spring is changed, this adjustment must necessarily be changed; and the re-adjustment, to show a vacuum with each spring, rests with the party using indicator.

Right and Left Hand Indicators.

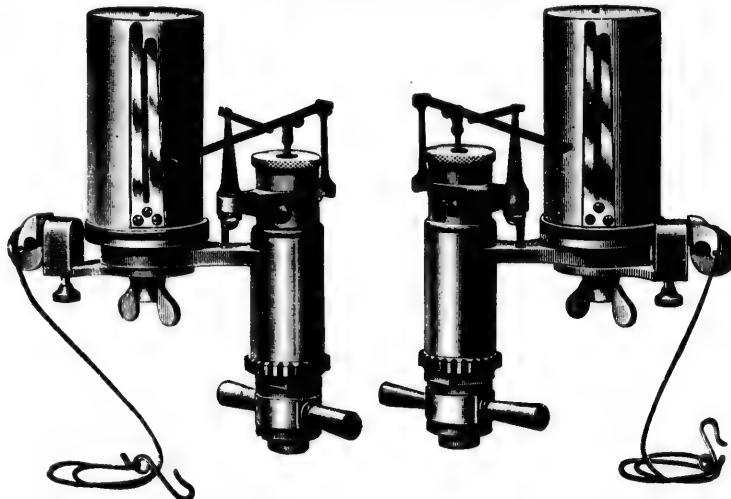


Fig. 4.—Right Hand.

Fig. 5.—Left Hand.

To facilitate the adjustment of the Thompson Improved Indicator to all styles and makes of engines, we make the Indicator right or left hand, as desired.

In a *right-hand* indicator, the pencil lever and connections, in

piston head.
and conven-
of any kind.
a pin or a
ring, discon-
not over $\frac{1}{8}$ of
me. When
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Indicator,
ring a com-
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ery time a
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pring, rests

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swinging away from the paper cylinder, swing to the right, and vice versa in a left-hand indicator.

By manipulating the cord-carrying arrangement, a right-hand indicator can be used right or left hand as desired; and the same is true of the left hand being used right hand.

NOTE.—In a left-hand instrument, the thumb screw for tightening or loosening the drum spring has left-hand thread; therefore when desirous of tightening or loosening the drum spring, start the thumb screw by turning to the right, or just opposite to a right-hand screw.

Detent Motion.

The Detent Motion, as applied to the Thompson Indicator, consists of a pawl mounted on a stud, in combination with a spring and ratchet, by the use of which the paper cylinder can be stopped and a change of cards made without un-hooking or disconnecting the Indicator cord.

By moving the pawl so as to catch in the teeth of the ratchet on

base of paper cylinder, (see Fig. 6) the latter is held stationary as the engine completes its stroke. The cord, being entirely free, runs loosely with the motion of the engine, but the paper cylinder being stationary, the cards can be changed without the least disturbance of adjustments. By throwing the pawl out of the ratchet the paper cylinder is released, and immediately resumes its stroke with the engine, but care must be taken not to allow the paper cylinder, by force of its spring, to return to the stop with a

thump; this can easily be done by simply holding the cord slightly with the thumb and finger until the beginning of the next stroke.

This device obviates the change of adjustments, and is particularly valuable to amateurs and others not familiar with the use of the

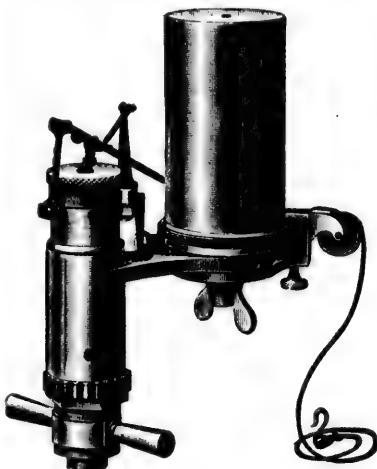


Fig. 6.

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Indicator. It is also valuable to users of the Indicator on very quick running electric light engines, and in all cases where the circumstances are such that the disconnection of the connecting cord must cause the operator considerable trouble, and the loss of valuable time.

Indicators are not equipped with Detent Motion unless so ordered, and when so equipped, a slight extra charge is made.

PRICE EXTRA FOR DETENT MOTION, \$3.00

Adaptability of the Thompson Improved Indicator for Extreme High Pressures.

Patented July 12, 1881.

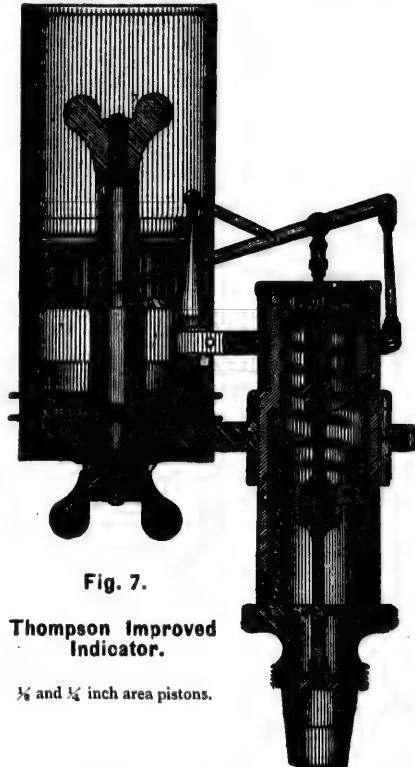


Fig. 7.

Thompson Improved Indicator.

$\frac{1}{8}$ and $\frac{1}{4}$ inch area pistons.

All Thompson Improved Indicators are provided with a piston .798 inch diameter = $\frac{1}{4}$ inch area, which, with the 100-pound spring, provides for indicating pressure up to 250 pounds.

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When pressure above that is to be indicated, we furnish an extra piston .564 inch diameter— $\frac{1}{4}$ -inch area, which, when substituted for the $\frac{1}{4}$ -inch area piston, doubles the capacity of each spring, thereby adapting the indicator for indicating pressures up to 500 pounds.

From the above, it will be seen, that when an indicator is furnished with the regular $\frac{1}{4}$ -inch area piston, and an extra $\frac{1}{4}$ -inch area piston in addition, the instrument can be used to indicate all pressures from 0 to 500 pounds.

PRICE OF EXTRA 1-4 INCH AREA PISTON \$10.00

Summing up the features of the Thompson Improved Indicator, it will be seen that it has advantages over all others in the following points :—

It is handsome in design,—mechanically and theoretically as near perfection as it is possible to obtain,—convenient, and simple in arrangement. All its moving parts are very light; and it is made of materials carefully selected and admirably fitted, thereby insuring durability. It is adapted for all pressures and speeds practicable, it is adapted for application to all situations, *and its simplicity and accuracy recommend it to those least experienced in the use of an indicator.*

General Use and Care of the Thompson Improved Indicator.

Before using indicator, take it apart, clean and oil it. Try each part separately. See if it works smoothly: if so, put it together without the spring. Lift the pencil lever, and let it fall: if perfectly free, put in the spring, and connect. Give it steam, but do not attempt to take a card until it blows dry steam through the relief. If the oil from the engine gums the indicator, always take it off and clean it.

Never use lead in connecting: it is not necessary, and is liable to get into the instrument. Attach indicator direct to the cock. The lighter the spring used, the higher will be the diagram produced, and, in consequence, the more accurate measurements can be obtained; therefore, in selecting a spring, select one to give diagram about two inches high.

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In selecting a suitable spring for a given pressure, always bear in mind the following general rule, as giving the maximum pressure to which each spring should be subjected: Multiply the number or scale of spring by $2\frac{1}{2}$, and deduct 15 for the vacuum allowance. Example: 40-pound spring $\times 2\frac{1}{2} = 100 - 15 = 85$ pounds pressure, maximum pressure of a 40 spring. For pressure less than the limit, of course, the spring may be used; but that rests with the operator's judgment.

To CHANGE THE SPRING.—First, unscrew the milled nut at the top of steam-cylinder; then take out piston, with arm and connections; disconnect pencil lever and piston by unscrewing the small-headed screw which connects them; remove the spring from the piston, substitute desired one, and put together in same manner.

The spring should always be firmly screwed to the shoulder; otherwise the pencil will not reach its proper position on the scale.

By means of the set screw which binds same, the revolving-pulley which guides the cord can be adjusted to guide the cord to any desired direction.

Diagrams with fine lines are always preferable; therefore use hard leads, same as sent with the indicator, and sharpen same with a sharp knife or fine file.

Use only porpoise or fine watch oil, such as sent with instrument, in oiling the indicator.

The indicator should always, after using, be taken apart, and thoroughly cleaned and oiled.

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THE THOMPSON IMPROVED INDICATOR.

During his term of office, Engineer-in-Chief Charles H. Loring, U.S.N., Chief of the Bureau of Steam-Engineering of the Navy Department, issued an order directing the commandant of the Boston Navy-Yard to appoint a board to test the Thompson Improved Indicator. The board consisted of two officers of the engineer corps, who made a very thorough test and a most favorable report as the following will show:

[COPY.]

UNITED STATES NAVY-YARD, BOSTON, COMMANDANT'S OFFICE,
March 2, 1885.

CHIEF ENGINEER F. A. WILSON, U. S. N., *Navy-Yard, Boston.*

Sir,—The board of which you are senior member will thoroughly test the Improved Thompson Indicator, submitted by the American Steam Gauge Company, of 36 Chardon Street, Boston, provided said test is made without cost to the government.

Your report, which will be in duplicate, will give a description of the article, and state its advantages and disadvantages for purposes under cognizance of the Bureau of Steam-Engineering, also whether it is recommended for purchase and use, as required by Act approved July 18, 1861.

The report on the Pop Safety Valve will also be made in duplicate, containing a description of the article, with your recommendation, etc.

Very respectfully,

(Signed)

O. C. BADGER, *Commodore Commandant.*

[COPY.]

NAVY-YARD, BOSTON, MASS., April 10, 1885.

Sir,—In obedience to the order of the commandant dated March 2, 1885, we have examined and tested the Improved Thompson Indicator manufactured by the American Steam Gauge Company, and respectfully submit the following report:—

The features of the instrument for which it is designated the "Thompson Improved Indicator" consists of one patented invention, a modification of some of its parts, and several additional devices.

They are as follows:—

1st, The improvement for which a patent has been granted, is a mechanical contrivance for guiding the cord on the paper cylinder, the imparted motion being from any possible direction. This is effected by means of a small grooved pulley affixed to a bracket having a short pin, which is fitted into a stand socket. The bracket, being free to revolve, can be placed to any required position, and held there by a thumb screw, which binds in a small groove in the pin, to prevent its defacement.

A hole through the pin guides the cord smoothly in the groove of the carrier disk for rotating the paper cylinder. The standard of the guiding-pulley is on a narrow disk, placed on a bolt underneath the base plate of the paper cylinder, and is held in position by a wing nut, which enables the disk to be readily adjusted.

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It is apparent that the adjustability of the guiding-pulley will give a smooth and regular rotation to the paper cylinder, no matter from what direction the motion may be imparted. The improvement is in keeping with the rest of the details of the instrument, and is an invaluable adjunct where the indicator motion is not a permanent fixture. It has no special advantage, however, for use on naval vessels, as the indicator motion is permanent and direct; but it will greatly facilitate the taking of cards from the air and circulating pumps.

2d, There is a modification of the pencil-carrying levers, whereby they are lightened, stiffened, and harmonized. Their principle and action, however, remain unchanged.

The working-lever is now a light steel rod forked at either end, jointed at the lower end to the body of the movable arm, and to the main lever at the upper end. The length of bearing is $\frac{1}{4}$ of an inch for the lower, and $\frac{3}{8}$ for the upper. The old style is a latticed plate, forked at either end, having equal lengths of bearing of $\frac{1}{2}$ of an inch. The main of pencil lever and radius link are of "drop" forged steel, the main lever being bossed on either side, to give greater stability of bearing at the piston and radius-bar connections, the width of bearing being .12 of an inch.

The bearing-pins for socket bar and piston connection are of steel, and threaded at the end; those for the radius bar are straight steel pins. The levers, forked end of piston rod, and trunk connections, have been much reduced in weight; and, although reduced to a minimum of lightness, the superior connections will give much greater durability.

The instrument without the improvements has a quaint, ungainly, and ancient look in comparison with the newer design.

The weights of the trunk, piston rod, and levers of parallel motion are, 31 grammes old design, and 15 grammes new design. Hence the latter is $\frac{31 - 15 \times 100}{31} = 51.6$ per cent. lighter than the former.

There being no reduction in the pistons, and being of equal weight, their weight is not included in the above.

3d, This improvement consists in the ratcheting of the base rim of the paper-cylinder carrier a short distance on its circumference at the limit of its rotation; this, in combination with a spring pawl, holds the cylinder when desired, and enables the user to take off the card and renew, without unhooking the cord. This will save trouble and much annoyance, which will be fully appreciated by every user of the instrument.

4th, This is a device to regulate the pressure of the pencil on the paper when tracing a diagram, and consists of a steel wire post riveted to the base plate of the paper cylinder, and a delicate handle of suitable length tapped through the movable arm, by which means a light line may be always assured; for with the pencil lightly placed on the paper, and the handle adjusted against the post, the heaviest hand must take as fine a card as a hand with the most delicate touch. This will be duly appreciated by those who have to use it in naval vessels, as the pencil can be adjusted before taking the instrument to the generally dim-lighted and hot place it is used in.

The instrument has been lightened by lowering the spring drum, thus shortening the spindle; also by reducing the length and thickness of material of the cylinder. A cap is brazed on the cylinder, having a central orifice, through which the spindle of spring drum passes for strengthening and steadyng the cylinder.

It has been lightened in every part that would admit of it.

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Tests were made with several different classes of engines, ranging in speed from 50 to 150 revolutions,—no higher speed could be found,—the steam-pressure varying in pressure from 60 to 90 pounds.

The tests were more than satisfactory, the improvements proving to be real and sensible.

The material used is of the finest quality, and the workmanship of a high order. All the workmen, having been engaged many years in instrument making, are reliable and skilful in all the details. The springs are tested by placing them in a machine which alternately compresses and extends them 1,500 times in a minute; this "jigging" process being done for the purpose of insuring the springs against any subsequent set, or change in the molecules of the metal when in use.

The cylinder and piston are fitted to a standard gauge, and are therefore interchangeable, as are all parts of the instrument.

The whole is nickel-plated.

The cost of the instrument complete is eighty-five dollars.

The senior member of the present board was senior member of a board to test the Thompson Indicator in 1879. The board reported favorably, and recommended its use in the United States Navy, since which time it has been in general use in naval vessels, and is therefore well known.

The improvements have added greatly to its accuracy, delicacy, sensitiveness, and durability; making the instrument about, if not wholly, as near perfection as can be obtained: and we have no hesitancy whatever in recommending its use in the naval service.

Very respectfully your obedient servants,

(Signed)

F. A. WILSON,

JAMES BUTTERWORTH,

Chief Engineers.

To COMMODORE LEWIS A. KIMBERLY, U.S.N.,
Commandant Navy Yard, Boston.

Since then valuable improvements have been made.

To substantiate all we claim for the Thompson Improved Indicator, we respectfully refer to the following indorsement of parties using them:—

TESTIMONIALS.

. . . In obedience to your order of Feb. 17, 1879, we have made a careful test of the Thompson Indicator, in accordance with the order of the Bureau of Steam-Engineering of Feb. 15, 1879, and respectfully submit the following report:—

A delicate handle is placed near the pencil, which, in combination with the less weight of moving parts, renders this instrument more sensitive to the touch when applying the pencil, which is a decided advantage.

American Steam Gauge Co., Boston.

Believing that this instrument is a reliable and sensitive one, we respectfully recommend its adoption in the naval service.

(Signed) F. A. WILSON, *Chief Engineer, U.S.N.*

G. M. L. MACCARTY, *P. A. Engineer, U.S.N.*

WM. H. HARRIS, *P. A. Engineer, U.S.N.*

To COMMODORE GEORGE M. RANSOM, U. S. N.,
Commandant U. S. Navy-Yard, Boston.

Note.—The Thompson Improved Indicator has been adopted by the United States Navy Department as the standard indicator.

OFFICE OF EDWARD P. ALLIS & CO.,
MILWAUKEE, WIS., MARCH 12, 1884.

AMERICAN STEAM GAUGE COMPANY, *Boston, Mass.*

Gentlemen,—In answer to your inquiry about New Thompson Indicator, I have to say, that, as now made, I consider it the best in use, and have come to this conclusion after using all the varieties now in the market.

Yours truly,

EDWIN REYNOLDS, *Superintendent.*

OFFICE OF PACIFIC IRON WORKS,
BRIDGEPORT, CONN., March 14, 1884.

AMERICAN STEAM GAUGE COMPANY.

Gentlemen,—Referring to the Thompson Improved Indicator which we purchased of you last year, would say that we have used it upon a great many high and low speed engines, both of our own and other builders' manufacture, and find that it gives perfect results and much satisfaction; and, in our opinion, it is the best indicator yet offered to the public.

Yours very respectfully,

P. H. SKIDMORE & SONS, *Pacific Iron Works.*

DELAWARE-RIVER CHEMICAL WORKS,
20 SOUTH DELAWARE AVENUE, PHILADELPHIA, Feb. 12, 1884.

AMERICAN STEAM GAUGE COMPANY.

Gentlemen,—Agreeable to your request of this date, as regards my opinion of the merits of the Thompson Improved Indicator, I unhesitatingly reply, that, during two years' practice with it and other classes of instruments, I have always found the Thompson thoroughly reliable, even under what is known as high speeds,—say a thousand feet per minute,—or locomotive practice; and, as long as it continues its present high state of perfection, I shall consider it an important adjunct to an engineer's outfit.

G. W. COOPER, M. E.

American Steam Gauge Co., Boston.

OFFICE OF THE JERSEY-CITY ELECTRIC LIGHT COMPANY,
No. 218 BAY STREET, JERSEY CITY, N. J., Feb. 6, 1885.

H. K. MOORE, Eng.

Superintendent American Steam Gauge Company, Boston, Mass.

I am delighted with the New Thompson Improved Indicator you recently furnished me. The new form of paper drum enables me to take diagrams up to six hundred revolutions per minute, without affecting in any sense their accuracy. The improved parallel motion is all that could be desired. At one time I had eight indicators of different manufacture, and found by comparison, that the Thompson has less faults than any of the others; therefore I call it my favorite, using it on all occasions where precision is necessary. A New Thompson Indicator should at all means be placed in every engine-room, where its judicious use will readily prove it a reliable check on the coal-pile.

Respectfully yours,

L. F. LYNE, *Superintendent.*

OFFICE OF THE FLINT MILLS,
FALL RIVER, MASS., Feb. 3, 1885.

AMERICAN STEAM GAUGE COMPANY, *Boston, Mass.*

Gents,— Your favor of the 31st of January, requesting a statement of the facts concerning the exchange of our Crosby Indicators for the Thompson Improved at our mills, is received and noted.

Replying, will say that some time ago we purchased, in good faith, a pair of Crosby Indicators, of the kind known as No. 2.

These instruments, from the first, were a source of trouble to us. The diagrams would show a loss, from boiler pressure, of seven to nine pounds, which no adjustment of the valve of our engine would remedy. The arrangement for changing springs in the Crosby instruments is complicated, and tedious to perform. The adjustment required in maintaining a proper height of pencil, especially for condensing-engines, like ours, is so fine and so easily disarranged, that we think, everything considered, the instrument unfit for ordinary every-day use.

With these facts in mind, we wrote you, requesting a pair of Thompson Improved Indicators for trial, with your best terms for the exchange.

We have had the Thompson Indicators three or four weeks, and are more than pleased with them.

The diagrams with these instruments show a difference of only one pound from boiler pressure, and a very fine distribution of steam, and this without any alteration in the valves of our engines. The arrangement in these instruments for changing springs is simple, readily understood, and quickly performed; and the height of pencil, once adjusted, is always the same. The swivel pulley for guiding the cord deserves special commendation, and we unhesitatingly pronounce the Thompson Improved Indicator to be the best indicator for our use we have yet seen; and we enclose check to balance our account. Please acknowledge the same, and oblige

Yours respectfully,

WM. S. POTTER, *Treasurer.*

American Steam Gauge Co., Boston.

BOSTON, June 1, 1884.

AMERICAN STEAM GAUGE COMPANY, *Boston, Mass.*

Gentlemen,— Having used the Thompson Improved Indicator on many different styles of engines, at speeds varying from seventeen revolutions up to three hundred and fifty, with marked success, I have no hesitation in saying that I consider the Thompson Improved Indicator a very valuable adjunct to an engine's or engineer's outfit.

Yours very truly,

C. H. ATKINS, *With the Knowles Steam-Pump Works.*

OFFICE OF C. A. SELEY,

Room 53, GILFILLAN BLOCK, ST. PAUL, MINN., March 14, 1884.

AMERICAN STEAM GAUGE COMPANY, *36 Chardon Street, Boston, Mass.*

Gentlemen,— I wish to indorse the Thompson Improved Indicator as a reliable, true instrument, and have been perfectly satisfied with its convenience of application to any situation. I have used it and others on locomotives, and high and low speed engines, with other indicators, and have never had cause to doubt it. I am, sirs,

Yours truly,

C. A. SELEY.

PHILADELPHIA, July 22, 1884.

AMERICAN STEAM GAUGE COMPANY, *Boston, Mass.*

Gents,— The Thompson Indicator which you furnished me has given me good satisfaction. I have used it frequently upon high-speed engines, with indicators of other makers, and have not yet had occasion to regret the choice which I made when I selected yours.

Respectfully yours,

H. L. BUTLER.

OFFICE OF THOMAS PRAY, JUN.,

BOSTON, MASS., July 23, 1884.

H. K. MOORE, *Superintendent American Gauge Company, Boston, Mass.*

In reply to your inquiry, I do not, have not, and shall not, make use of any indicator except the Thompson Improved, of your make, in my work on adjusting, indicating, etc., until I find something better. I have tried them all, and use none but Thompson's in my practice. The little Fellow No. 2 is the best high-speed indicator now out. Have used it at six hundred and forty per minute. And your springs and indicators, as now made, are the best I have ever seen or used.

Respectfully,

THOS. PRAY, JUN.

CALUMET AND HECLA MINING COMPANY,

OFFICE OF CONSULTING ENGINEER, CAMBRIDGEPORT, MASS., Jan. 24, 1885.

AMERICAN STEAM GAUGE COMPANY, *36 Chardon Street, Boston.*

Gents,— In reply to your favor of the 23d, I am pleased to state that I regard

American Steam Gauge Co., Boston.

June 1, 1884.

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I consider the
or engineer's

Pump Works.

March 14, 1884.
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as a reliable,
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I am, sirs,

A. SELEY.

July 22, 1884.

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PRAY, JUN.,
23, 1884.
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24, 1885.
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your Improved Thompson Indicator as the best instrument of its kind extant, and invariably order it for both fast and slow speed engines. It is the only instrument which has proved satisfactory on our steam stamp.

Yours truly,

E. D. LEAVITT, JUN., Consulting Engineer.

STEVENS INSTITUTE OF TECHNOLOGY,
HOBOKEN, N. J., May 28, 1884.

AMERICAN STEAM GAUGE COMPANY, Boston, Mass.

Gentlemen,—Yours of the 27th is received. In reply I take pleasure in saying that the pair of Thompson Indicators to which you refer are in frequent use in the work of the mechanical laboratory of the Stevens Institute of Technology, and are a very important part of its outfit. The recent changes made in the construction of the instrument, with a view to adapting it to use on "high-speed engines," are, in my opinion, very decided improvements; and the new arrangement for leading off the cord from the paper cylinder is as handy as it is neat and ingenious. I am very much pleased with these improvements upon what was originally a very excellent instrument.

The steam-engine indicator is so essential a part of every engineer's outfit, that these steps in the direction of securing precision in its work are of special interest to every member of the profession.

Very respectfully yours,

R. H. THURSTON.

OFFICE OF NATIONAL ASSOCIATION OF STATIONARY ENGINEERS,
DETROIT, MICH., May 30, 1884.

AMERICAN STEAM GAUGE COMPANY, Boston, Mass.

Gentlemen,—Replying to yours of the 27th inst., relative to the usefulness of the indicator in general as an engineer's outfit, would say every man who aspires to the calling of an engineer should own one, and use it. Its reading, combined with a little brain work, will save engineers and firemen many hours of manual labor, besides, in many cases, a source of profit to the employer; and I firmly believe, that, when its benefits are more widely known and appreciated, employers will only engage men as engineers who are versed in indicator practice, and will remunerate them accordingly.

Respectfully yours,

A. M. DAVY.

THE SKENANDOA COTTON COMPANY,
UTICA, N. Y., May 27, 1884.

AMERICAN STEAM GAUGE COMPANY, H. K. MOORE, Superintendent.

Dear Sir,—In reply to yours of the 24th, have to say that the Thompson Improved Indicator and Planimeter, purchased of you last November, have been in daily use since. Having instructed my engineer how to use them and adjust the valves, he is required to take cards with the indicator four times each day, work them up, and report the average horse-power, pounds of coal used, pounds of coal

American Steam Gauge Co., Boston.

per horse-power per hour, and the cost of each horse-power per hour and report to the office at the end of each week.

I enclose cards taken during the last five months, to show whether the valves are properly adjusted or not.

I believe both instruments should be furnished to the engine-room as a part of its outfit, and the engineer instructed how to use them, especially for engines of a hundred or more horse-power.

My engineer and fireman have become as much interested in the economical working of the engine as they would if they had to furnish the coal themselves. The engineer has used the indicator on a neighbor's engine, making two hundred and twenty revolutions per minute; and the cards show clear and distinct lines, as on slow-running engines.

I am trying four different kinds of soft coal, and expect to be able to tell the relative value of the coals by the indicator.

Yours truly,

L. R. SCOTT, *Superintendent.*

.... In response, I would say that the Thompson Indicator is the most precise instrument of its kind I have any knowledge of

With the Thompson Indicator I have obtained diagrams from locomotive engines at speeds varying between two hundred and three hundred revolutions per minute and have found the lines as regular and precise as at speeds of fifty to a hundred with same engine

JOHN W. HILL, *Consulting Engineer.*

CINCINNATI, O.

AMERICAN STEAM GAUGE COMPANY, 36 Chardon Street, Boston, Mass.

Gentlemen,— In reply to yours of the 27th would say that we keep in constant use from this office six of the Thompson Indicators, some of which have been rebuilt from the Richards Instrument, with greatly improved results. As our practice is mostly with high-speed work, our instruments are severely tested; as for instance, equalizing the valve motion at two hundred revolutions to cut-off at one per cent. of the stroke under eighty pounds of steam. The Thompson Indicator performs this service perfectly, which cannot be said of any other instrument within our knowledge.

Yours respectfully,

WM. LEE CHURCH,

NEW YORK.

OFFICE OF BUCKEYE ENGINE COMPANY,

SALEM, O., Feb. 3, 1880.

AMERICAN STEAM GAUGE COMPANY, 36 Chardon Street, Boston, Mass.

Gentlemen,— We have had several of the Thompson Indicators in constant use ever since their first introduction, applying them to engines of all sizes and speeds, and working under all pressures and grades of expansion usually met with in engineering practice, and have never met with a single instance in which the amount of vibration was sufficient to impair the value of the diagram produced. Previous to its introduction, it was not an uncommon thing in our experience, in indicating

American Steam Gauge Co., Boston.

engines running at high or moderately high rotative speed, and working expansively under good pressure, to encounter such excessive vibration as to render the results worthless; and, independently of the question of vibration, we have found that its other merits (which will be apparent to engineers of any degree of familiarity with indicators) are such as to give it a decided superiority under all circumstances.

The marvellous delicacy and perfection of its action cannot be better illustrated than by the accompanying cut, which represents a friction card taken by ourselves from one of our 16 by 32 inch cut-off condensing engines. It represents conditions under which distortion from vibration would naturally be very excessive with the most improved instrument.

The card is one of a number taken while adjusting the condenser, and stopping air leaks. Speed of engine, ninety revolutions per minute; scale, forty pounds. Five-inch throttle open.

Very truly, etc.,

BUCKEYE ENGINE COMPANY,

PER JOEL SHARP, President.

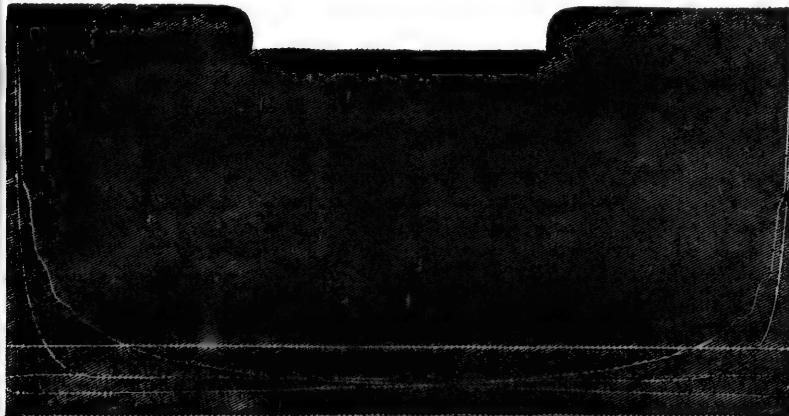


FIG. 8.

OFFICE OF FRANK H. POND, 214 NORTH EIGHTH STREET,
ST. LOUIS, Feb. 3, 1880.

AMERICAN STEAM GAUGE COMPANY, 36 Chardon St., Boston, Mass.

Gentlemen,—Your favor of the 29th is at hand. In reply, would say regarding the Thompson Indicator, having used both that and the Richards, I consider it far superior in sensitiveness and ease of motion, and well adapted to be used on the quick-running engines of the present day. There have been many improvements embodied in the Thompson which experience has shown to be necessary, and it seems to meet all practical requirements.

Yours truly,

FRANK H. POND.

American Steam Gauge Co., Boston.

ST. LOUIS GAS-LIGHT COMPANY, NO. 511 OLIVE STREET.

ST. LOUIS, March 21, 1882.

AMERICAN STEAM GAUGE COMPANY, 36 Chardon Street, Boston, Mass.

Gentlemen,—Please forward by express, C. O. D., one No. 12 and one No. 20 spring for Thompson Indicator, No. 240.

Have been using your indicator for over a year, and consider it a beautiful instrument, delicate and fine in its action, and a pleasure to work with.

If you have no No. 12, send No. 16 instead.

Yours truly,

JOHN SOBOLEWSKI.

CINCINNATI, OHIO, Mar. 8, 1889.

AMERICAN STEAM GAUGE CO., Boston.

Gentlemen,—I have used Thompson Steam Engine Indicators for fifteen years, in fact, ever since they were first introduced, and have at all times and under all conditions of engine service, found them entirely reliable.

In all my experience I have never had occasion to complain of the manner in which they performed, and if I were buying Indicators today I should buy the Thompson.

I do not know that I can express my regard for these invaluable instruments in any stronger language.

Very respectfully,

JOHN W. HILL, C. E.

CALUMET & HECLA MINING COMPANY.

OFFICE OF THE CONSULTING ENGINEER, CAMBRIDGEPORT, MASS., Mar. 6, 1889.
AMERICAN STEAM GAUGE CO., 36 Chardon Street, Boston.

Gentlemen,—I have to say that after quite an extensive use of the Thompson Indicator, I am persuaded that it is a most excellent instrument, and that my confidence in the same is proven by the orders from time to time sent your company.

Yours truly,

E. D. LEAVITT, JR., Consulting Engineer.

SIBLEY COLLEGE, CORNELL UNIVERSITY.

ITHACA, N. Y., March 12th, 1889.

Gentlemen,—It gives me great pleasure to say that the instruments sent us have proved to be of most excellent quality, and so far as our work has given opportunity to judge, of great accuracy. We have used them on all kinds of work, and at speeds of rotation up to 300, and have found them capable of doing admirably.

The finish is excellent and the sizes and fits are all that could be desired. They have been very useful, both in class work and in making engine trials, and eminently satisfactory in all respects. We have had no difficulties with them except such as have come from their use by inexperienced hands.

When used for instruction an occasional accident is to be expected. They have withstood such injuries quite as well as we ought to expect, and have done more work and better work, even in such hands, than I had supposed possible.

Very respectfully yours,

R. H. THURSTON, Director.

American Steam Gauge Co., Boston.

EDW. P. ALLIS & CO., RELIANCE WORKS,

MILWAUKEE, WIS., Mar. 14, 1889.

AMERICAN STEAM GAUGE CO., Boston, Mass.

Gentlemen.—I have used all the prominent makes of Indicators, but very much prefer the Thompson, and believe it has more good points and less faults than any other instrument made. The easy changing of springs, good leading pulley for the cord, general convenience in handling, and last, but certainly not least, its ability to stand abuse, are some of the features that commend it to the practical engineer.

Yours truly,

IRVING H. REYNOLDS.

PRICES OF THOMPSON IMPROVED INDICATOR AND EXTRA FIXTURES.

Thompson Indicator complete, with one spring, in the instrument, one scale, two cocks, all necessary wrenches to use on the instrument, one screw-driver, one bottle watch-oil, and Pray's "Twenty Years with the Indicator," all enclosed in a neat mahogany box	\$85.00
Thompson Indicator, with the above fixtures, and nickel-plated	88.00
Extra Piston, $\frac{1}{4}$ -in. area	10.00
" Springs	each 5.00
" Box-wood Scales	" .50
" Steel Scales	" 1.50
" Cocks	" 2.75
" Elbows	" 2.50
Three-way Cock	6.00
Single Carrying-Pulley	.60
Double "	1.20
Parallel Rule	7.00
Reducing-Pulley	25.00
Clamps	3.00
Metallic Cards	per thousand 15.00
Common Cards	" " 7.50
Detent Motion	3.00
Pantograph	10.00
Planimeter	15.00

STEEL INDICATOR.

The regular Thompson Indicator is made of Brass almost entirely, and would not stand the action of the ammonia used in Ice or Refrigerating Machines. For these machines we make Thompson Improved Indicators all steel, to withstand the action of the ammonia.

Price, all complete, with fixtures as above enumerated in price-list \$140.00

American Steam Gauge Co., Boston.

TO ENGINEERS.

Every man aspiring to the calling of an engineer should own and use an Indicator; and, although the subject may at first seem too deep, it is nevertheless true, that any engineer can, with the assistance of the book of instructions sent with each instrument, learn to use the indicator with satisfactory results in a short time.

To engineers we can allow *special terms*, and will furnish particulars upon application. We solicit correspondence on the subject.

The following parties use the Thompson Improved Indicator; also a great many others who have procured the instruments of our agents:—

Alex. Pollock, Engineer	New York.
John Roach & Son, Steamship Builders	New York.
Charles W. Copeland, Consulting Engineer	New York.
William Lee Church, Consulting Engineer	New York.
Henry W. Bulkley, Consulting Engineer	New York.
A. & F. Brown, Engineers	New York.
H. A. Rogers, Engineer	New York.
S. R. Kirby, Engineer	New York.
Delamater Iron Works, Steamship Builders	New York.
James Beggs & Co., Engineers	New York.
William Cramp & Sons, Steamship Builders	Philadelphia, Penn.
T. B. Bickerton & Co., Engineers	Philadelphia, Penn.
Harlan & Hollingsworth Company, Steamship Builders, Wilmington, Del.	Wilmington, Del.
The Pusey & Jones Company, Steamship Builders	Bristol, R. I.
Herreshoff Manufacturing Company, Engineers	St. Louis, Mo.
M. C. Bignall, Mechanical Engineer	St. Louis, Mo.
Frank H. Pond, Mechanical Engineer	Fall River, Mass.
Sanford & Covell	Lawrence, Mass.
W. F. Sherman, Mechanical Engineer	Boston, Mass.
Whittier Machine Company, Engine Builders	Worcester, Mass.
Washburn & Moen Manufacturing Company, Wire Manufacturers	Fitchburg, Mass.
W. C. Johnson, Engineer	Macon, Ga.
Schofield Iron Works	Pittsburgh, Penn.
Atwood & McCaffrey, Engineers	Pittsburgh, Penn.
H. H. Westinghouse, Engineer	Boston, Mass.
Hill, Clarke & Co.,	Bound Brook, N. J.
Henry L. Einstein	Baltimore, Md.
Reuter & Mallory, Engineers	Washington, D. C.
United States Navy Department	

American Steam Gauge Co., Boston.

John W. Hill, Consulting Engineer	Cincinnati, O.
Goulds & Ostrander, Engineers	St. Louis, Mo.
North Star Iron Works	Minneapolis, Minn.
Lane & Bodley Company	Cincinnati, O.
Conant Thread Company	Pawtucket, R. I.
Grand Trunk Railroad of Canada	Montreal.
Frazer & Chalmers, Engineers	Chicago, Ill.
Holly Manufacturing Company, Engineers	Lockport, N. Y.
Portland Company, Locomotive Builders	Portland, Me.
Pennsylvania Railroad	Philadelphia, Penn.
E. D. Leavitt, jun., Mechanical Engineer	Cambridgeport, Mass.
William A. Harris, Engine Builder	Providence, R. I.
George T. McLaughlin & Co.	Boston, Mass.
Randolph & Co.	Central City, Col.
George S. Beers, Engineer	New Milford, Conn.
Parke & Lacey, Engineers	San Francisco, Cal.
W. T. Garratt & Co., Engineers	San Francisco, Cal.
Edward P. Allis & Co.	Milwaukee, Wis.
Woodbury, Booth & Pryor, Engineers	Rochester, N. Y.
Frank E. Kirby, Mechanical Engineer	Detroit, Mich.
Atlas Engine Works, Engine Builders	Indianapolis, Ind.
J. A. Lauder, Supt. M. P. O. C. R. R.	Boston, Mass.
Calumet & Hecla Mining Company	Calumet, Mich.
F. R. Redpath, Consulting Engineer	Montreal, Can.
Constant Meese, Sugar Refining	San Francisco, Cal.
Robert Wetherill & Co.	Chester, Penn.
American Rubber Company	Cambridge, Mass.
Robert Whitehill	Newburg, N. Y.
Wardell & Hinckley	Chicago, Ill.
American Tool and Machine Company	Boston, Mass.
Cincinnati Water Works	Cincinnati, O.
R. O. Moorhouse	Philadelphia, Penn.
Nonantum Worsted Company,	Newton, Mass.
John H. McGowan Company	Cincinnati, O.
Hartford Engineering Company	Hartford, Conn.
Natchez Cotton Mills	Natchez, Miss.
Eliot B. Mayo	Boston, Mass.
California Paper Company	San Francisco, Cal.
Pacific Mills	Lawrence, Mass.
Brush Electric Company	Cleveland, O.
W. Bingham & Co.	Cleveland, O.
Rand Drill Company	New York.
Massachusetts State Prison	Concord, Mass.
Denver Foundry and Machine Company	Denver, Col.
Erie and Western Transportation Company	Buffalo, N. Y.
Yale Lock Manufacturing Company	Stamford, Conn.
Utica Steam Cotton Mills	Utica, N. Y.
George S. King	Pittsburgh, Penn.
Cambria Iron Company	Johnstown, Penn.

American Steam Gauge Co., Boston.

C. Stewart & Son	Worcester, Mass.
William Berwick	Hill Grove, R. I.
S. A. Goodwin	Philadelphia, Penn.
Morton, Reed & Co.	Baltimore, Md.
Nagle & Kamp	Hamburg, Germany.
Thomas Shaw	Philadelphia, Penn.
Hallowell Cotton Manufacturing Company	Hallowell, Me.
St. Paul and Sioux City Railroad Company	Shakopee, Minn.
Chicago, Rock Island and Pacific Railroad Company	Chicago, Ill.
John Gauge	Washington, D. C.
University of Minnesota	Minneapolis, Minn.
University of Wisconsin	Madison, Wis.
Stephens Institute	Hoboken, N. J.
Massachusetts Institute of Technology	Boston, Mass.
Cornell University	Ithaca, N. Y.
R. F. Power	Leadville, Col.
J. W. Birkett	Brooklyn, N. Y.
Boston Rubber Shoe Company	Malden, Mass.
J. Firmenich	Buffalo, N. Y.
Crane Iron Company	Catasauqua, Penn.
Exeter Machine Works	Exeter, N. H.
St. Louis Gas-Light Company	St. Louis, Mo.
North River Iron Works	New York.
Arlington Mills	Lawrence, Mass.
Utica Steam Gauge Company	Utica, N. Y.
Cleveland Rolling-Mill Company	Cleveland, O.
D. P. Stewart	Buffalo, N. Y.
Buffalo Grape Sugar Co.	Buffalo, N. Y.
Otto C. Woolf	Philadelphia, Penn.
Whittenton Manufacturing Company	Taunton, Mass.
Otis Iron and Steel Company	Cleveland, O.
Bass Foundry and Machine Company	Fort Wayne, Ind.
M. F. Pennywell	Racine, Wis.
Henry Parsons	Newark, N. J.
H. S. Robinson	Boston, Mass.
Globe Mill	Woonsocket, R. I.
Stephen Sanford	Amsterdam, N. Y.
G. Hall, jun.	So. Willington, Conn.
Thomas Pray, jun.	Boston, Mass.
Door, Sash, and Lumber Company	Cleveland, O.
Bay State Iron Company	Boston, Mass.
Knowles Steam-Pump Works	Boston, Mass.
George D. Putnam & Co.	Boston, Mass.
N. E. Weston Electric Light Co.	Boston, Mass.
E. L. Sanford	Boston, Mass.
Tileston & Hollingsworth	Boston, Mass.
George F. Blake Manufacturing Company	Boston, Mass.
E. B. Vannevar	Boston, Mass.
The Lockwood Manufacturing Company	Boston, Mass.

American Steam Gauge Co., Boston.

Mass.	Boston, Mass.
R. I.	Providence, R. I.
Penn.	Pittsburgh, Penn.
Md.	Baltimore, Md.
Germany.	Bremen, Germany.
Penn.	Philadelphia, Penn.
Me.	Portland, Me.
Minn.	Minneapolis, Minn.
D. C.	Washington, D. C.
Minn.	St. Paul, Minn.
is.	Chicago, Ill.
J.	Edgewood, N. Y.
s.	Chester, Penn.
.	Chicago, Ill.
pl.	So. Framingham, Mass.
Y.	Stoughton, Mass.
s.	Trenton, N. J.
Y.	Chittenango, N. Y.
Penn.	North Adams, Mass.
.	Lawrence, Mass.
.	New York.
ass.	St. Louis, Mo.
Penn.	Little Falls, N. Y.
s.	New York.
nd.	New York.
R. I.	Ansonia, Conn.
Y.	St. Paul, Minn.
Conn.	Hartford, Conn.
	Lancaster, Mass.
	Burlington, Vt.
	E. Bridgewater, Mass.
	New York.
	So. New Market, N. H.
	Meriden, Conn.
	Amesbury, Mass.
	Philadelphia, Penn.
	Detroit, Mich.
	Manchester, N. H.
	Nashua, N. H.
	Providence, R. I.
	Providence, R. I.
	Providence, R. I.
	Hamilton, O.
	Rutland, Vt.
	Cleveland, O.
	Baltimore, Md.
	York, Penn.
	Pittsfield, Mass.
	Manchester, N. H.

American Steam Gauge Co., Boston.

Eagle Iron Works	Eau Claire, Wis.
A. G. Phillips	Butte City, Mon.
O. H. Perry	Lowell, Mass.
Thomas H. Connell	Lowell, Mass.
T. W. Hugo	Duluth, Minn.
Columbian Manufacturing Company	Greenville, N. H.
Charles A. Richards	Bridgeport, Conn.
Barnaby Manufacturing Company	Fall River, Mass.
P. H. Skidmore & Son	Bridgeport, Conn.
Watts, Campbell & Co.	Newark, N. J.
George W. Williams & Son	Charleston, S. C.
Sterling Organ Company	Birmingham, Conn.
J. K. Clark	Butte City, Mon.
Canadian Locomotive and Engine Company	Kingston, Ont.
Robert Rodman	La Fayette, R. I.
R. H. Thurston	Hoboken, N. J.
B. S. Nichols & Co.	Burlington, Vt.
James A. Platt	Chester, Penn.
J. F. Ridgeway	St. Louis, Mo.
P. & F. Corbin	New Britain, Conn.
N. O. Nelson Manufacturing Company	St. Louis, Mo.
C. H. North & Co.	E. Cambridge, Mass.
E. G. Studley & Co.	Grand Rapids, Mich.
Walsh, De Roo & Co.	Holland, Mich.
David Jenkins	Sheboygan, Mich.
E. H. Gowing	Reading, Mass.
Bowman & Kellogg	Atchison, Kan.
Green & Daniels Manufacturing Company	Pawtucket, R. I.
Joyce, Cridland & Co.	Dayton, O.
Shanghai C. C. Mill Company	Shanghai, China.
James Sheriffs	Milwaukee, Wis.
The Bozrahville Company	Bozrahville, Conn.
China Manufacturing Company	Suncook, N. H.
Schaffer & Budenberg	New York.
Joliet Steel Company	Joliet, Ill.
George H. Gilbert Manufacturing Company	Ware, Mass.
Webster, Camp & Lane Machine Company	Akron, O.
Southwalk Foundry and Machine Company	Philadelphia, Penn.
Anaconda Gold and Silver Mining Company	Butte City, Mon.
Melrose Milling Company	Evansville, Ind.
Rockdale Mill	Northbridge, Me.
Hope Company	Hope, R. I.
Rhode Island Electric Light Company	Providence, R. I.
R. M. Lodge	Philadelphia, Penn.
F. H. Hayes	Holyoke, Mass.
Pacific Mill	Lawrence, Mass.
I. R. Scott	Utica, N. Y.
Rhode Island Locomotive Works	Providence, R. I.
Struther, Wells & Co.	Warren, Penn.

American Steam Gauge • Boston

E. F. Osborne	St. Paul, Minn.
Neafie & Levy	Philadelphia, Penn.
Newmarket Manufacturing Company	Newmarket, N. H.
Jarvis Barnes & Co.	Lansing, Michigan.
E. P. Watson & Son	New York.
A. M. Davy	Detroit, Mich.
Grosvenor Dale Company	Grosvenor Dale, Conn.
Cummer Engine Company	Cleveland, O.
Charles E. Jacks	Central Falls, R. I.
Rufus K. Townsend	Albany, N. Y.
Iron Bay Manufacturing Company	Marquette, Mich.
Saunders Cotton Mill	Saundersville, Mass.
Rees, Shook & Co.	Pittsburgh, Penn.
H. L. Nott	Norwich, Conn.
J. H. Hecox	Westborough, Mass.
H. Warrington	Chicago, Ill.
Jackson Foundry and Machine Company	Jackson, Mich.
Monadnock Mill	Claremont, N. H.
Nordyke and Marmon Company	Indianapolis, Ind.
Michigamme Company	Michigamme, Mich.
Wallace & Brother	Baltimore, Md.
Morgan Envelope Company	Springfield, Mass.
Corliss Steam-Engine Company	Providence, R. I.
Frank A. Foster	New Haven, Conn.
Daniel Ashworth	Cincinnati, O.
D. W. Murphy	Beverly, Mass.
L. W. Cummings	Waterbury, Conn.
John W. Turner	Mazeppa, Minn.
Edwin Stanger	Philadelphia, Penn.
E. C. Perry & Co.	Dunkirk, N. Y.
J. Snow & Co.	Tuscaloosa, Fla.
Silver Spring Bleaching and Dyeing Company	Providence, R. I.
Edward Watson	Newark, N. J.
William B. Bement & Son	Philadelphia, Penn.
S. C. Forsaith & Co.	Manchester, N. H.
Fitchburg Steam-Engine Company	Fitchburg, Mass.
Phoenix Chair Company	Sheboygan, Wis.
J. K. Foss	Reading, Mass.
S. M. Van Cleef, M. E.	New York.
W. R. Smith	Oswosso, Mich.
New York Safety Steam-Power Company	New York.
Exposition Cotton Mill	Atlanta, Ga.
A. J. Van Ness	New York.
H. R. Worthington	New York.
Lewis Johnson	New Orleans, La.
F. Van Winkle, M.E.	New York.
E. F. Williamson	Philadelphia, Penn.
Merchants' Mill	Dedham, Mass.
American Triple Thermo Union	New York.

American Steam Gauge Co., Boston.

J. F. Rogers & Co.	Philadelphia, Penn.
Montgomery Ice Manufacturing Company	Montgomery, Ala.
Edison Electric Illuminator Company	Brockton, Mass.
Thomas Manning, jun.	Cleveland, O.
W. A. Howland	Lowell, Mass.
W. G. Coyle & Co.	New Orleans, La.
Whitney Iron Works	New Orleans, La.
Doran & Smith	Le Sueur, Minn.
Laurel Lake Mills	Fall River, Mass.
Dodge Manufacturing Company	Witanaka, Ind.
Novelty Iron Works	New Orleans, La.
Phoenix Iron Company	Trenton, N. J.
William Wright	Newburg, N. Y.
Williams & Orten Manufacturing Company	Sterling, Ill.
I. E. Swift	Ishpeming, Mich.
Irwin & Beissner	Galveston, Tex.
Eismayer Company	Little Rock, Ark.
A. L. Archambault	Philadelphia, Penn.
E. M. Burna, Receoni	Northfield, Mass.
Geldon Brothers	Columbus, Ga.
John N. Paul	Middletown, O.
Allegheny City Water Works	Allegheny, Penn.
H. Firmisteer	Longdale, Va.
Goodyear Metallic Rubber Shoe Company	Naugatuck, Conn.
C. P. Williamson	Birmingham, Ala.
Richmond Paper Company	Providence, R. I.
W. H. Clohem, jun.	Utica, N. Y.
Milwaukee Machine Company	Milwaukee, Wis.
G. H. Morrison	Pacific, S. C.
National Tube Works	McKeesport, Penn.
Colt's Patent Fire-arms Manufacturing Company	Hartford, Conn.
Strong Locomotive Engineering Company	Philadelphia, Penn.
E. F. Davis	Pottsville, Penn.
John C. Froehlich & Co.	Baltimore, Md.
S. E. Cobb	Terre Haute, Ind.
Lynn Iron Company	Birmingham, Ala.
A. D. Travers	Cleveland, O.
Frank Mitchell	E. Killingly, Conn.
J. Hendy Machine Works	San Francisco, Cal.
Swain, Earle & Co.	Boston, Mass.
Cooke & Co.	New York.
Anton Borges	New York.
Braman, Dow & Co.	Worcester.
Charles E. Rice	Lockland, O.
Oshkosh Water Works	Oshkosh, Wis.
Abiles, Cook & Co.	Little Rock, Ark.
Kensington Engine Works	Philadelphia, Penn.
Hancock Inspirator Company	Montreal, Can.
Warren A. Carr	Brockton, Mass.

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THOS. PRAY, JR., Consulting Engineer,

95 MILK STREET (Room 71), BOSTON.

BOSTON, MASS., Oct. 24, 1890.

LIBRARY STEAM GAUG Co., Boston, Mass.:

Condition. — Your inquiry of Oct. 23, asking me "to give you my decided opinion of the merits and demerits of the Thompson improved indicator, as manufactured by your company," is the first time in a professional career of more than twenty years that any corporation ever asked me to tell them the outs of their instruments.

You also make a second inquiry "with reference to what was my experience with the Thompson indicators on the second official trial of a United States steam cruiser "Baltimore," built by the William Cramp & Sons' Ship and Engine Building Company for the United States government, Navy Department."

To the second inquiry I can only answer in a general way. I was employed by the William Cramp & Sons' Ship and Engine Building Company to investigate the reason why the cruiser "Baltimore" only made 8,977.2 horse-power on her first official trial, and to suggest any improvements which could be made, etc. After a careful examination of the diagrams in the judge advocate's office of the Navy Department of the United States, at Washington, and some ten days spent over the drawings, models, etc., in Cramp & Sons' ship-yard, and on the ship examining the engines, I suggested certain changes which should be made and which were afterward made by consent of Engineer-in-Chief Melville, of which alterations I had personal charge for Cramp & Sons, by consent of the Navy Department. All of these changes were inspected by the officers of the United States government then on duty at Cramp & Sons' ship-yard.

When the alterations were finished, I was sent to the New York Navy Yard, where I acted jointly with certain officers of the United States Navy Department, detailed by Engineer-in-Chief Melville, and under the immediate personal supervision of Chief Engineer Dungan, of the New York Navy Yard, and I assisted in the official test of the

Thompson indicators made by your company for the Navy Department, for the cruisers "Baltimore" and "Philadelphia," preparatory to the instruments being sent to the ship to take the diagrams which would form the basis of settlement between the Navy Department and Cramp & Sons, which was on the basis of \$100 for every indicated horse-power made by the ship above 9,000, during the official trial run of four consecutive hours. This statement is necessary in order to convey an idea of the importance attached to that trial, as well as the test which preceded it, and also to enable me to answer your first question, from the circumstances which can only be brought out by answering the second question first in order.

The builders of the ship were under a guarantee to furnish 9,000 indicated horse-power, in which they failed on the first official trial, by a fraction less than 23 indicated horse-power.

The engines were supposed to be capable of more than 10,000 indicated horse-power. It is unnecessary to say here what alterations were made, or why; but after the alterations were made in the engines, as is stated earlier in this letter, we commenced the test of each instrument and spring with the mercury column and steam gauge, these being the "standards used" in the United States Navy Yard at New York, neither of which instruments were made by your company. Very early in the test I filed an objection, which Chief Engineer Dungan, on careful examination, immediately allowed, and the instruments were then tested by a standard test gauge made by your company, corrected for the mercury column (in which we found errors). Then the corrections of the corrected mercury column were worked out for the steam gauge, and found to be slight, and all the indicator springs were tested at five and ten pound intervals, according to the requirements of the Bureau of Steam Engineering of the Navy Department, and upon this basis, after the official trial, all the corrections were made in computing the horse-power of the ship.

When we came to test the low-pressure cylinder springs, I filed a written objection to the standard instrument furnished by its builders to the Navy Department, called a vacuum test gauge.

This objection of mine called forth a very spicy letter from the Bureau, which was received only an hour before I left the Navy Yard with the instruments and the officers in whose custody they were to be sent on board the "Baltimore."

We went to sea Nov. 13, anchoring that night near the Delaware

breakwater. The next day we went to the open sea with the ship for our own test, and I ran the engines of the "Baltimore" with 125 pounds of steam at 118.6 revolutions for over two hours, during which time Chief Engineer S. L. P. Ayres, in charge of the engineering corps, very courteously acceded to my request to have the assistants read the indicators on the engines of the "Baltimore" and take some cards, that I might get at the action of the valves and make any further changes which were necessary for the official trial that was to occur the following day. The action of the instruments on Thursday, to which reference was made immediately above, was everything that could be desired. After the United States officers had taken cards, which were handed over to me for computation, the instruments were returned, each one to the custody of the man who was to manipulate it on the morrow, and the ship was headed back for her anchorage inside the breakwater.

On Friday, the 15th of November, we left the breakwater about six o'clock A. M., and went directly out to sea and ran the ship from 7.25 to 7.55 under a full head of steam, when Chief Engineer Ayres commenced the official test of four hours.

At twelve o'clock M., after running four hours and five minutes, officially, not a single accident had occurred to any one of the indicators from any fault of the indicator. Not a single card was omitted, nor was a single card soiled or lost, twelve indicators being used on both engines and four on the auxiliary machinery, diagrams being taken at intervals of fifteen minutes; the whole 192 cards of main engines being formally numbered and filed, not a single one of which contained a single inaccuracy which prevented its being computed. During that time two of the indicators were seriously injured in the pencil bar, only by the carelessness of a man in passing up or down the ladders between the ratings in catching the leg of his pants in the pencil motion. These were immediately replaced by others (Thompson's) to complete the official record. Aside from this, no mishap occurred to any one of the instruments. The high-pressure cylinder, carrying 123 to 125 pounds of steam on the diagram, engines running at about 118 revolutions per minute, the auxiliary running from 700 revolutions per minute to as low as 32 strokes on the pumps, some of the places being difficult of access, and others being where a man had to step over the indicator every time an observation was made.

Now and then a cord broke, and in one or two cases men lost a screw, but these were replaced, as I had provided myself with them.

The result, therefore, of the test of the Thompson indicators is faultless, so far as operation, adjustment, and accuracy are concerned.

The derangements which occurred were not the fault of the instruments, their design or construction, and no trial of any naval vessel, either American or foreign, that I have ever attended, went off in so completely and thoroughly successful a manner as did that of the "Baltimore," so far as indicators were concerned, on her second official trial.

In the previous official trial, which took place in September, 1889, Thompson indicators were only used to replace two instruments of another make, used on the high-pressure cylinder, where a part of the cap blew off, crippling the instruments, and these two crippled indicators were replaced by two Thompson indicators which were on the ship, and they performed the rest of the duty in a perfectly satisfactory manner. The Thompson instruments were employed on the Brotherhood engines, making 700 revolutions per minute, which were used in the fire-rooms: they were used on the pumps, making 32 strokes, on the auxiliary condenser, on the electric-light engine, running at 375, answering perfectly in every place the requirements of the occasion.

This is perhaps sufficiently explicit to answer your second question.

Now as to your first inquiry, I have yet to come in contact with the first steam gauge or indicator in the United States to-day that is absolutely correct, and this refers not only to the instruments made by your company, but to those made by other companies as well. My personal experience in this matter is undoubtedly as good as that of any man living.

Fourteen years ago the standards of a foreign government were corrected absolutely, and the objections which I filed with the Navy Department while in the employ of Wm. Cramp & Sons, on the United States cruiser "Baltimore," from the New York Navy Yard, about Nov. 26, 1889, have resulted in Engineer-in-Chief Melville, United States Navy, detailing a man who was thoroughly capable to visit the New York Navy Yard in January or February, 1890, to examine into my objections to the supposed standards then in use, and the final result has been that the scale of the mercury column was found incorrect in itself, and that no part of the supposed standard instrument which was in use at the time my objections were filed with Chief Engineer Dungan now remain in existence, excepting the steel tube

staining the mercury, the float, the wheel, and the index from which mercury scale was read. The vacuum test gauge has been entirely abandoned. A new vacuum gauge, of which I furnished the drawings, has been arranged, with some slight modifications. The mercury column has been corrected for latitude, height above the sea level, and gravity factor which must enter into all physical calculations, and a steam-engine indicator spring and a mercury column and a vacuum gauge are all within the realm of physics, it is safe to say that unless Stevens Institute and the New York Navy Yard have a near approximation to a correct mercury column, there does not exist in the United States to-day, Oct. 24, 1890, a mercury column or a vacuum gauge that is correct. It must follow that the standards not being absolute, the results of graduating any instrument whatever from these standards *must necessarily be as incorrect as the standards (?)*.

Men who make instruments for sale usually consider that, if their instruments are as good as others, they are all right.

This does not answer your question fully, in my way of putting it. If your instruments are incorrect, they are wrong, and that is exactly my basis. Indicator springs give to-day, as a rule, from seven to as high as thirteen per cent more power on an engine than they would give if the springs were correct. The indicated horse-power of the United States cruiser "Baltimore" by the instruments which had been tested, while the engines were running on Thursday, Nov. 14, computed 10,821 horse-power *without correction*. The official computation of the power for the four hours' run was 10,119.68 horse-power. This makes a difference of 701.32 horse-power, which was deducted from the reading of the indicator diagrams in order to make the correct amount of power exerted on the combined main and auxiliary engines in that ship for that day. Had the indicator diagrams been absolutely correct, it would have added over \$70,000 to the sum paid by the Navy Department to Wm. Cramp & Sons, which was \$119,000, as between the guaranteed and the actual result of the second official trial, Nov. 15, 1889.

It remains for you, therefore, as the oldest steam-gauge company in this country, if I am correct, to put yourselves in a position to make absolute instruments for commercial use, which can only be done by going to the very foundation with a man who is capable of working out the results, and you can have as nearly absolute instruments as any observatory in the world.

This question has never yet been considered in any industrial concern in the United States, except in an approximate way. It is a question of several thousands of dollars to do this properly, and then it may be a question of expense after that to arrange your springs, the friction of the instrument, and various other physical questions, which can only be done from a careful investigation; but I hope that you will at no late day take this question up and be able to offer a correct steam gauge, a correct vacuum gauge, and a hydraulic pressure gauge. In order to do this, the exact latitude of your factory must be ascertained, its precise height above the level of the sea, and then the absolute weight of a pound of mercury at that point, under a certain temperature, and the gravity factor of the distance from the centre of the earth, which makes a difference in the weight of a pound of steel, iron, mercury, or water, must also be included, and correctly.

These things have been made of no account, and my proposition to the Navy Department was at first ridiculed as far as courtesy would allow; and Engineer-in-Chief Melville certainly deserves a great deal of credit for carefully looking into the matter afterward and availing himself, for the first time in the history of the Navy Department of the United States, of all these quantities, and correcting the scales for latitude, gravity, and temperature. The lack of what Mr. Melville has done has been sharply criticised by the engineering profession the world over, and personally I congratulate myself as an American that it has finally been thoroughly done.

It is only a question of time when every concern that pretends to manufacture an indicator, steam gauge, vacuum gauge, mercury column, or any other instrument by which pressure or vacuum is to be measured, must calculate the instrument for the precise spot on the earth where it is to be located and used. A steam gauge made in Boston, with latitude, gravity, and temperature corrections, may be carried to any latitude or longitude in the world, and will correctly record the problems offered to it or observed from it. A pound of mercury is different in Philadelphie, New York, Boston, Portland, or London, Paris, or Naples.

It remains to be seen now whether your concern has the enterprise to lead off in this, or whether some competitor will do it. The day has evidently passed for selling instruments which have no foundation in fact, when submitted to physical observation and correction. Some of our clock makers have found this out by expensive experience.

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This will, perhaps, answer your questions, using more space than I anticipated; but to answer them fully and go into details would interfere very seriously with three books which will shortly be brought out by my publishers, to which you and the general public will be referred for full particulars.

Personally and professionally I have been accused of too much favoritism for the Thompson indicator. My reasons for such preferences are as follows: —

It is over twenty-five years since your company made the first pair Richards indicators, which I used. It has been my privilege to see every instrument ever made that had any reliability. Years ago I said, what I can to-day say stronger than ever, that when I am on a steamship, a locomotive, or any other of the larger engines on which I only work now, I use the Thompson indicator for the adjustment of valves exclusively, from the fact that its delicate record of the changing of position of the valves is not equalled by any other instrument that I have ever yet seen or used.

I use any indicator for general work which the parties have or desire to use. I have tested the springs of all indicators, and am now on a committee to further these tests, which has already been nearly one year in existence.

I have to-day the largest engines in the world to look after, and on several steamers, which for the last five years I have had charge of, have invariably used the Thompson improved indicator made by your company.

I have only wished that they were absolute, or within an exceedingly small limit of absolute, as it would save a vast amount of time in computation, and there is no reason why the instrument cannot be made practically absolute, in a commercial way, with ordinary care.

The fact that five hundred indicators are used now where one was used ten years ago would seem to be a sufficient incentive to do this work. All of which is respectfully submitted.

Yours truly, THOMAS PRAY, JR.

NOTE.—As to the capacity of the Thompson indicators, I can only say that I have used the Thompson No. 1 on four hundred and thirty-five revolutions per minute (see "Twenty Years with the Indicator," pages 162, 163), and the Thompson improved No. 2 on six hundred and forty-two revolutions by the register (see "Twenty Years," pages 217-224). Since that time the No. 2 instrument has done work at seven hundred and twenty revolutions per minute, by actual mechanical counting.

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American Steam Gauge Co., Boston.

H. T. Bartlett	New York.
A. W. Stahl	La Fayette, Ind.
Griffin Manufacturing Company	Griffin, Ga.
Charles A. Hague	Chicago, Ill.
Novelty Machine Works	Evansville, Ind.
Pullman Palace-Car Company	Chicago, Ill.
M. F. Pennywell	Hamilton, O.
W. H. Jameson	Wilson, Kan.
Burnham Hanson	Dover, N. H.
James Krieff	Magnoville, Cal.
Boston Woven Hose Company	Boston.
Bertram Brothers	New York.
O. Matheson & Co.	New Glasgow, S. C.
Crook, Horner & Co.	Baltimore, Md.
John M. Leach	Evansville, Ind.
John Post, jun., & Co.	Boston, Mass.
H. C. Burke	St. Paul, Minn.
P. A. Noble	Springfield, Mass.
John Exton	Trenton, N. J.
F. Grote & Co.	New York.
E. O. Kelsey	Lowell, Mass.
Whitten Cotton Mill	Providence, R. I.
Carnegie, Phipps & Co.	Pittsburgh, Penn.
Paterson Association Stationary Engine	Paterson, N. J.
Canadian Pacific Railway	Montreal, Can.
G. A. Know	Boston, Mass.
Fred Wolff	Chicago, Ill.
Remington & Henthorn	Providence, R. I.
Allen Print Works	Providence, R. I.
James Lockart	Philadelphia, Penn.
Baltimore & Ohio R.R. Co.	Baltimore, Md.
Frank L. Cottrell	Union City, Pa.
E. T. Dixon	Millbank, S. D.
Geo. Hornung	Cincinnati, O.
Andrew Ringwald	Fly Mountain, N. Y.
Thomas M. Wilson	Independence, Mo.
J. A. Crouthers	New York, N. Y.
Jas. Milne	Montreal.
The W. Bingham Co.	Cleveland, O.
Reid & Creighton	Fall River, Mass.
Fred. Phelps	Newark, N. J.
Milwaukee, Lake Shore & Western Ry. Co.	Milwaukee, Wis.
E. I. Noxon	Jamestown, Dak.
C. H. McCutcheon	Buffalo, N. Y.
Strong & Trowbridge	New York, N.Y.
A. G. Turner	Willimantic, Ct.
Jas. W. Birkett	Brooklyn, N.Y.
Blue Ridge Marble Co.	Nelson, Ga.
Walter Barnsdale	Los Angeles, Cal.

American Steam Gauge Co., Boston.

Iowa Iron Works Co.	Dubuque, Ia.
John Rourke	Savannah, Ga.
Eclipse Wind Engine & Pump Co.	Beloit, Wis.
Rockwell Machine & Car Co.	Sandusky, O.
J. W. Holmes	Paducah, Ky.
A. J. Wilkinson & Co.	Boston.
American Steam Boiler Insurance Co.	New York, N.Y.
Milwaukee Cement Co.	Milwaukee, Wis.
Robert Barnsdale	Coronado Beach, Cal.
L. C. Baumgarten	Hornellsville, N.Y.
Hydraulic Milling Co.	Wichita, Kan.
Foster's Wharf Co.	Boston.
The J. Morton Poole Co.	Wilmington, Del.
Russell, Boynton & Co.	Minneapolis, Minn.
The Hooven, Ownes & Rentschler Co.	Hamilton, O.
The Geo. Worthington Co.	Cleveland, O.
Willamette Steam Mill	Portland, Ore.
Calumet & Hecla Mining Co.	Calumet, Mich.
John Mathie	Knoxville, Tenn.
Dallas Cotton & Woolen Mills	Dallas, Tex.
Robinson & Cary Co.	St. Paul, Minn.
Star Brass Mfg. Co.	Boston.
Warner & Co.	New Orleans, La.
The Engineers' Co.	Chicago, Ill.
National Transit Co.	Oil City, Pa.
Cleveland Supply Co.	Cleveland, O.
Wilmington Water Works	Wilmington, Del.
Skenandoa Cotton Co.	Utica, N.Y.
The Weisel & Vilter Mfg. Co.	Milwaukee, Wis.
Holyoke Machine Co.	Worcester, Mass.
Russell & Co.	Massillon, O.
Christ. Dannheiser	Mt. Vernon, O.
Elmira Water Works	Elmira, N.Y.
Charleston Water Works	Charleston, S.C.
Temple St. Cable Railway Co.	Los Angeles, Cal.
Bowker & Tripp	New Bedford, Mass.
U. S. Wind Engine & Pump Co.	Batavia, Ill.
Towle Mfg. Co.	Newburyport, Mass.
Sherman Oil & Cotton Co.	Sherman, Tex.
Horace C. Thomas	Petersburg, Ind.
Dallas Water Works	Dallas, Tex.
Chicago Steel Works	Chicago, Ill.
J. T. Elliott	Duluth, Minn.
Falls City Jeans & Woolens Co.	Louisville, Ky.
Morss & Whyte	Boston.
E. W. Thurston	Neenah, Wis.
The Journal Co.	Kansas City, Mo.
Jos. B. Smith	Chester, Pa.
McIntosh, Huntington & Co.	Cleveland, O.

American Steam Gauge Co., Boston.

Fox Machine Co.	Grand Rapids, Mich.
Ira Winsor & Co.	Providence, R.I.
West Point Foundry Co.	West Point, Ga.
Providence Steam Engine Co.	Providence, R.I.
Chas. Reeder & Sons	Baltimore, Md.
Chas. H. Bowers	Chester, Pa.
Buffalo Steam Pump Co.	Buffalo, N.Y.
Ashland Iron Mining Co.	Ironwood, Mich.
Knoxville Foundry & Machine Co.	Knoxville, Tenn.
Plymouth Cordage Co.	Plymouth, Mass.
Concordia Electric Light Co.	Concordia, Kan.
The Eaton, Cole & Burnham Co.	New York, N.Y.
Pittsburgh Traction Co.	Pittsburgh, Pa.
Columbian Iron Works & Dry Dock Co.	Baltimore, Md.
Oliver & Imboden Co.	Wichita, Kan.
P. P. Kellogg & Co.	Springfield, Mass.
Hutchinson Water, Light & Telephone Co.	Hutchinson, Kan.
Mark L. Thomas	Wheeling, W. Va.
Mexican Central R. R. Co.	Boston.
R. M. Spedden & Co.	Baltimore, Md.
Frank Slater	Fitchburg, Mass.
Fitchburg Gas Co.	Fitchburg, Mass.
The I. & E. Greenwald Co.	Cincinnati, O.
Sherriff Machinery Co.	Pittsburgh, Pa.
J. S. Paine	Boston.
Wm. M. Mathiesen	Chicago, Ill.
Wilkin Mfg. Co.	Milwaukee, Wis.
Brush Elect. Light & Power Co.	Memphis, Tenn.
Connecticut River Lumber Co.	Mt. Tom, Mass.
Liddell, Hunter & Co.	Dallas, Tex.
Home Electric Light & Power Co.	Shelbyville, Ind.
Brush Electric Light Co.	Galveston, Tex.
School of Technology	Atlanta, Ga.
John A. Peebles	<i>Yokohama, Japan.</i>
Cooley & Vater	Minneapolis, Minn.
Portland Cordage Co.	Portland, Ore.
Major W. R. Livermore, U.S.A.	Newport, R.I.
Wm. J. Silver	Salt Lake City, Utah.
Woonsocket Spool & Bobbin Co.	Woonsocket, R.I.
C. J. Reilly	Denver, Col.
New Orleans Railway & Mill Supply Co.	New Orleans, La.
Frontier Iron & Brass Works	Detroit, Mich.
Lindsay & Robson	Humboldt, Kan.
Stearns, Roger & Co.	Denver, Col.
Rix & Firth	San Francisco, Cal.
Porter Mfg. Co.	Syracuse, N.Y.
Globe Iron Works Co.	Cleveland, O.
Fort Worth Electric Light Co.	Fort Worth, Tex.
Robert Wylie	Cincinnati, O.

American Steam Gauge Co., Boston.

Schenectady Locomotive Works	Schenectady, N.Y.
L. Prescott	Omaha, Neb.
Clark Sintz	Springfield, O.
Jacob Doid Packing Co.	Kansas City, Mo.
Frank Jones	Portsmouth, N. H.
E. & A. H. Batcheller & Co.	No. Brookfield, Mass.
University of Kansas	Lawrence, Kas.
Geo. Millbank	Chillicothe, Mo.
D. A. Wise	Topeka, Kan.
Irving H. Reynolds	Milwaukee, Wis.
Hall & Co.	Jamestown, N.Y.
H. P. Gregory & Co.	San Francisco, Cal.
E. M. Goodall	Philadelphia, Pa.
Little Falls Wool Extract Co.	Little Falls, N.Y.
Henry A. Vesin	Great Falls, Mont.

American Steam Gauge Co., Boston.

THE STEAM-ENGINE INDICATOR.

Benefits Derived and Information Ascertained from its Use.

The benefits derived, and the information ascertained from the use of the steam-engine indicator, are varied and important.



FIG. 9.

We quote, by permission from "Hill's Manual," published by William A. Harris, builder of the Harris-Corliss steam engine, Providence, R. I. :—

"The office of the indicator is, to furnish a diagram of the action of the steam in the cylinder of an engine during one or more revolutions of the crank, from which is deducted the following data: Initial pressure in cylinder; piston stroke to cut-off; reduction of pressure from commencement of piston stroke to cut-off; piston stroke to release; terminal pressure; gain in economy due expansion; counter pressure if engine is worked non-condensing; vacuum as realized in the cylinder, if engine is worked, condensing; piston stroke to exhaustclosure, usually reckoned from zero point of stroke; value of cushion; effect of lead and mean effective pressure on the piston during complete stroke. The indicator diagram, when taken in connection with the mean area, and stroke of piston, and revolutions of crank for a given length of time, enables us to ascertain the power developed by engine; and when taken in connection with the mean area of piston, piston speed, and ratio of cylinder clearance, enables us to ascertain the steam accounted for by the engine.

"The mean power developed by engine compared with the steam delivered by the boilers, furnishes the cost of power in steam, and, when compared with the coal, furnishes the cost of the power in fuel.

"The diagram also enables us to determine with precision the size of steam and exhaust ports necessary, under given conditions, to equalize the valve functions; to measure the loss of pressure between boiler and engine; to measure the loss of vacuum between condenser and cylinder; to determine leaks into and out of the cyl-

American Steam Gauge Co., Boston.

inder; to determine relative effects of jacketed and unjacketed cylinders; and to determine effects of expansion in one cylinder, and in two or more cylinders."

—By permission of Thomas Pray, jun., editor of "The Boston Journal of Commerce," we publish here-with one account of the practical application of the indicator, which will show the importance of its application.

"The diagrams illustrated in the present article are of more than passing interest, and were taken from the engine of a man who places no value on its attachment. It is only necessary to say to the experienced man, that the diagrams were only taken when he found that something was the matter which his engineer could not manage; and this is only one of the numerous applications of the value of the indicator, which the expert in its use is continually meeting. The engine in question is a Harris-Corliss, 14 inches diameter of cylinder, 42 inches length of stroke, 60 revolutions per minute; the pressure in the boiler varying from 65 to 75 pounds. The diagrams *A* and *B* are from the different ends of the engine; *B* being the crank end, and *A* the head end. *B* is one of these peculiar-looking diagrams which we frequently meet with in actual practice, more especially from engineers who know exactly how to set their valves by a scratch or prick punch mark; and they can tell exactly how she takes steam by watching the cut-off slide. The engineer in this case simply had to give it up; and, if he had gone a few steps farther, his engine would have run the other way. The diagram *A* shows three lines as they were taken from the instrument, and they are most wretchedly irregular lines too. The steam line is as full of humps as a camel's back, and the notches and irregularities are the exact counterpart of the movements or action of the steam as it is admitted to the cylinder. The admission line in itself is very late. The steam valve commences to open only after the piston has commenced its stroke. It does not open fully until after the piston has travelled several inches. The exhaust will be seen to be very late, both upon *A* and *B*. It is comparatively small in its showing upon *A*, from the fact that the diagram *A* shows a very much lighter load than that of *B*. The amount of power, 32.4-horse

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power, given on *A* is the mean of three lines; the largest amount being plus 50, and the smallest only 22. *B* has the same general outline as *A*; but in this case

A was set to cut off at less distance than *B*; so that *B* is only a single line, and is doing three-quarters the work of the engine. The line in the case of *B* is very bad indeed. The valve does not commence to open until after the piston has started on its return stroke. The cut-off is very badly defined, and might lead to the idea that the valves were badly leaking; but no experienced engineer would try to ascertain this question until the valves were in proper position. The toe at the end of the expansion, at the commencement of the exhaust line, is an additional amount of work thrown away. This is only a fair specimen of the way that many engineers get their valves; and they are always found in the hands of those people who do not use the indicator, and who frequently make the assertion that they do not believe in the indicator, for it is of no use. All such are perfectly welcome to their belief; and their employers sometimes change their minds when the engine has been properly indicated and adjusted by people who do believe in the indicator, and who know how to apply it, and read properly its results.

FIG. 11.



taken altogether is a very good production. It is needless to say that a very considerable saving of fuel resulted as the difference between the engineer's setting, *A* and *B*, and that of the man who applied the indicator, *CD*. These diagrams are from actual practice, and were given us by Mr. Mosiman of the American Steam Gauge Company. They were taken with 40 springs, and the engine at its regular work. Probably the question never entered the head of the engineer in charge as to the result of the use of steam as in the diagrams *A* and *B*. The steam in *A* is admitted in all sorts of quantity in the endeavor of the regulator to reach after and equalize the load which is done in the other end of the cylinder; but as the cut-off slides are

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set at *B* to cut off longer than is necessary, and at *A* are set shorter than they should be, it is simply impossible for the regulator to adjust the difference between them; for the difference is so great that the regulator cannot measure it by the differential strokes of the cut-off slides, or the motion which is given them through the change of position of the balls on the governor. In this case the crank end of the engine is doing more than double that of the head end, and these motions of the head end are shown in the irregular steam lines by its race after the other end of the engine; and exactly in proportion as these lines differ from each other, was the resistance or the strain upon the different parts of the engine; differing at each end of the stroke, making 120 times a minute after its load, and the regulator is simply unable to adjust the difference, or, in other words, is attempting to accomplish an impossibility. The engine in this case is using something like forty per cent or more steam than would be necessary when properly adjusted, as is seen in the figure *C* and *D*; and this is only another important lesson that people can learn if they will, but usually only learn when they are obliged to. And it is all the more to the credit of the indicator that it is able to show up, in the hands of an experienced manipulator, these points where pocket value is the point attained; and in a case like this the amount of coal burned before and after adjustment is a factor that can always be measured in dollars and cents, and this is the standard of too many steam-users in quite an opposite direction."

USING THE INDICATOR.

To Attach to the Cylinder.

The importance of the indicator is now so generally recognized by all engine-builders, that nearly all first-class engines are sent from the shops with cylinder already drilled for its application. When no provision has been made for the application of the indicator, holes must be drilled and tapped with not less than half-inch pipe tap, in such position in the side of the cylinder, that when the piston is at the ends of its travel, they will be as nearly as possible in the centre of the clearance space, and yet not be obstructed by the piston when at its extremes of travel.

In drilling, great care must be taken not to allow any chips to get into the cylinder; and, when the heads cannot be removed, it is better to turn on a little steam as the drill begins to enter, in order to blow the cuttings out.

It is usually most convenient to remove a strip or two of the lagging, and drill into the cylinder at the top or back side.

Should the clearance be too small to allow of this, the tap may be made directly into the head, which it is desirable to avoid, to bring the indicator into a convenient position; the object being always to

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have the indicator connected as directly as possible to the cylinder : and in all cases where the circumstances will permit, the indicator cock should be screwed into the cylinder itself. When the tap is on the side of the cylinder, by use of nipples and elbows, which we can furnish, the indicator can be brought into a vertical position, the same as if tapped on top of cylinder.

We do not recommend the use of a half-inch angle valve upon the end of a nipple, into which the indicator cock is screwed. Where the arrangement is to be permanent, it is much better to have an indicator cock for each end of the cylinder, which may be neatly capped when not in use, preventing anything from getting into the pipe ; offering a much neater appearance, and, what is of more consequence, less obstruction to the steam. Obviously the most proper arrangement for indicating an engine is to have an instrument upon each end of the cylinder, from which simultaneous diagrams may be taken.

This arrangement shows its advantages where engines are constantly changing their load, and where it is desired to test the equalization of the work between the two ends of the cylinder.

When, however, a single indicator is to be used upon both ends of the engine, the best method is, to connect by means of side pipes and a three-way cock : the disadvantages arising from this indirect connection being more than counterbalanced by the facility with which the instrument can be switched from one end of the cylinder to the other without loss of but one revolution, and without disturbance of the connection with paper drum, and by the fact that diagrams

are obtained from both ends of the cylinder on the same card.

The turns in this Three-way Cock are made on a quarter-turn, and not on sharp angles, as in the old style.

**PRICE OF THREE-WAY COCK
WITH SLIP JOINT TO ALLOW FOR EXPANSION, ALL
NICKEL-PLATED - - \$6.00**



FIG. 12.—Three-Way Cock.

When, however, as is sometimes done, angle valves are placed on the ends, instead of elbows, and no three-way cock at the centre, the arrangement is in its most objectionable form, and the resulting diagrams will present an appearance similar to that produced by deficient lead and obstructed induction.

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The Reducing Motion.

It is unnecessary for us to explain or even enumerate the different devices that have and can be used for this purpose. The ingenuity of the operator will suggest many different ways; but the essential requisite for such a device is, that it shall give to the paper drum a movement which is a perfect duplicate in miniature of that of the piston of the engine. Many arrangements in use fail to do this; in fact, it may and does frequently happen that the distortion is so considerable as to give deceptive records.

Take, for instance, the most common and easily rigged plan,—the pendulum lever pivoted to any convenient fixed support above the engine, and linked at its lower extremity to the cross-head by a short connecting-bar, so attached as to incline about as much above a horizontal line at the extremes of travel as it does below at mid-travel. When the upper end of this pendulum is furnished with a segment of a pulley on which the cord leading to the instrument winds and unwinds, it is sometimes called the "Brumbo pulley."

With this arrangement, the drum movement will, in the absence of any distortion from cord-stretching, be an exact copy of that of the lever; but *the latter will not be an exact copy of the piston movement*. The connecting-bar is virtually shortest when inclined upward or downward: hence there are two points in the movement of the lever, something less than one-fourth of its travel from its extremes, where it is farther from its point of attachments to the cross-head than at the extremes; and any events, as the cut-offs for instance, will be made to appear unequal when they are really equal. The distortion is greatest when the lever and the connecting-bar are short. If the former is one and a half times the stroke, and the latter half or more, the distortion will not be serious, though it will exist. A pin or screw in the lever will give less distortion than the segment, provided it is so placed, that, when the piston is at mid-stroke, a line placed between it and the pivot of the lever will be at right angles with the cord; otherwise the movement at one end of the travel will be too fast, and too slow at the other.

The most correct, and at the same time most convenient, arrangement for reducing the motion of the cross-head without any distortion whatever is the pantograph.

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THE PANTOGRAPH.

We are the only parties who make a perfect pantograph, nicely made, close-fitting, and positive and snug motion.

In describing it and its mode of application, we quote from an article by "Chordal" in the "American Machinist," Dec. 27, 1879.

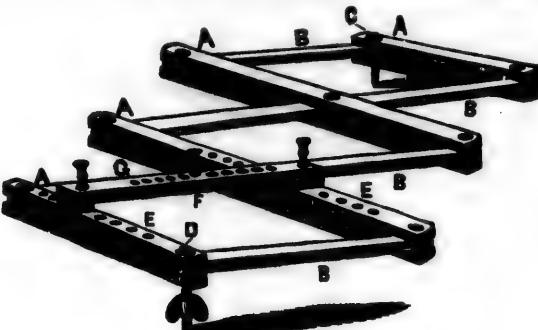


FIG. 13.

CORLISS'S DRUM MOTION.—I call this a Corliss device, because, while he may not have invented it, he has been using it for years, and is the only person I know of to blame for its being known and used. It is now manufactured and for sale by the American Steam Gauge Company of Boston. It consists of a lazy-tongs system of levers. The long levers are of cherry wood, sixteen inches between centres, one and one-eighth by five sixteenths; those marked *B* being single strips, and those marked *A* being double strips. This makes the thing very stiff and substantial. The pivots should be got up in good style, and the pivot holes bushed. The hitch strip *G* should be arranged so that it may be shifted in the holes *E*, and bring a hitch pole, *F*, in a line passing through pivots, *CD*. The end pivots *C* and *D* should have a projection below of, say, two inches, with the end somewhat pointed. Any one who attempts to make one of these things will have fun. The least variation in the location of the pivot holes will cause the levers to refuse to act. No dimensions are essential: and if the thing will close up nicely and open out nicely, it is all right; if it won't do both, it is all wrong. The engine cross-head must have a vertical hole in it somewhere, so that pivot *C* can be dropped into it. A stake must be set in the floor near the guides, having a socket for the pivot *D* in its top. The stake socket must be level with the cross-head socket, and must be directly opposite the cross-head socket when the latter is at mid-stroke. The indicator cord is hooked to the centre peg *F*; and the stake should set at such a distance from the guides that the cord will lead off parallel with the guides. Otherwise a guide pulley will be called for. When this rig is in motion, every point on a line cutting *CD* has a true motion parallel with the guides, varying in distance from nothing at *D* to length of a stroke at *C*. It is only necessary to hitch the cord at a point on this line which will give the right amount of motion to the cord. This point will be near *D*, and within the range of adjustment of the strip *G*. This is as neat a device as could be wished for. I have seen Mr. Corliss's men hook on to an engine running

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at a good gait, without stopping. Mr. Corliss, I think, is in the habit of putting a permanent socket into his cross-head, and setting a nice standard in a floor socket. Indicator cocks are kept on the cylinder at all times. For a permanent rig on a nice engine, the stake can normally support a neat table-top for oil-cans and waste."

PRICE \$10.00

A variety of other forms of attachments can be and are sometimes used, according to circumstances; but the ones herein described are the most common and accurate.

 On p. 45 the Indicator is shown with the Pantograph attached.

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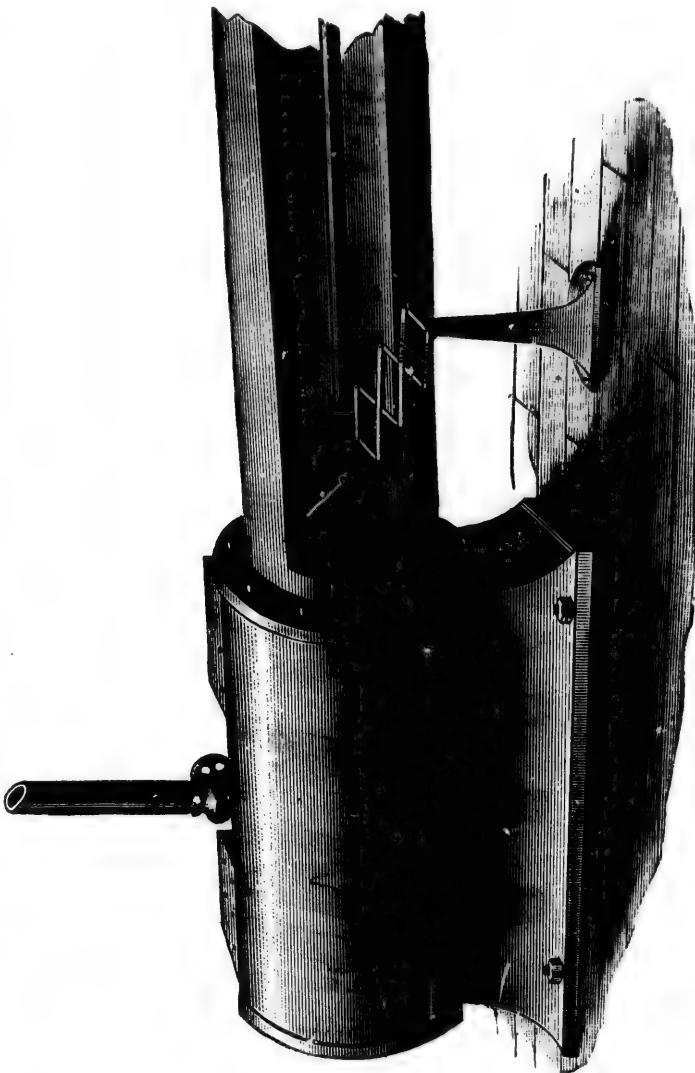


FIG. 14—Indicator with Pantograph attached.

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BACON'S PATENT PANTOGRAPH ATTACHMENT.

[FROM "TWENTY YEARS WITH THE INDICATOR."]

This simple little affair is the invention of F. W. Bacon, for many years consulting and indicating engineer, and is the outcome of those annoying and perplexing delays and hinderances that are so often found by the indicating engineer, who is travelling from place to place, making his attachments, and putting up what we usually term the rigging. It would hardly be considered a credit to many manu-



FIG. 15.

factoring concerns if the real paucity of mechanical appliances which they possessed were known, and that it is a fact that many of them have not even a hand-saw or an ordinary nail-hammer.

Before the lazy tongs, or pantograph as it is now known, was introduced, we have ourselves frequently spent more time in putting up or down, or somewhere

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else, the pendulum, or some other ingenious makeshift to properly transmit the reduced motion from the cross-head or trunnion of the engine, than we have in indicating, adjusting and finishing up all the rest of the work. It was to obviate these frequent and annoying delays that our friend Bacon invented the device of which we are now to speak.

Fig. 16 shows, in detail, all the parts of this attachment. *A*, *B*, are two joined links made of thin sheet-iron riveted together. The short piece is upon different sides of the long piece; so that the long pieces, *A* and *B*, when locked under a nut, will bring the holes through which the pantograph is attached, so that, while one overlaps the other, the nut under which the long pieces are clamped will lie in a perfect line without disturbing the grip of the nut. *C* is a screw which can be either put through the holes shown in the end of the short link screwed into the piece *D* in the hole in the end, or, if the pendulum is required, it can be attached to either one of the holes in the side of the larger part. *E* is a simple thumb nut, which can be used in either case. The whole arrangement can be carried in your vest-pocket, or in a coat-pocket, without any trouble.

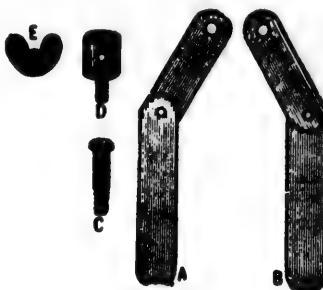


FIG. 16.

Fig. 15 shows how Mr. Bacon's attachment is applied to one of the adjusting-nuts which steady the cross-head on the brass ways; while the cross-head lies in a horizontal plane, as in many of our old-fashioned horizontal engines. One of these adjusting-screws is lifted a little, the two long links are shut under each side of the screw underneath the head, and the head then screwed down upon them, making it perfectly rigid, but at the same time not altering any adjustment of the engine. Here a little point must be borne in mind by the party who is applying this device. It will be seen, by reference to Fig. 15, that we have attached the device to the back end of the cross-head on the outside of the guide, and that we must allow the cross-head to travel precisely as far one way as the other, and must take the end of that side of the cross-head to which we have made the attachment for our centre line, and not calculate from the centre nut shown on that side of the cross-head. Now, the post, the top of which is shown in Fig. 17 which supports the other end of the pantograph, must be exactly square with the portion of the cross-head to which we have attached the pantograph, when the cross-head is in precisely the centre of its travel; in other words, we must allow the difference between the central nut and the one on the end, as shown, from which to obtain our central line. The arms of

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the pantograph are shown shut up as much as they can be when attached properly. The support of that end of the pantograph from the post which is shown at its outer arms, and the cord-screw in the short cross-bar, must be precisely in line when the pantograph is in this position, else the diagram is worthless. The end of the post must be high enough so that the pantograph lies perfectly easy, and without any cross-friction or draught. We have spoken so particularly in previous lessons of the attachment of the pantograph, that but little remains here to be said except to describe the motion.



FIG. 17.

Fig. 17 shows the application of the Bacon attachment to a perpendicular guide, or cross-head, which is vertical. In this case, the two links are run under the connection between the cross-head proper and the brasses or guides. The head of the post is also shown.

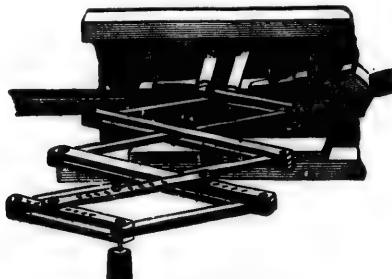


FIG. 18.

In Fig. 18 we have the Corliss guide, where the links are put under the adjusting screw at the top. This may be done by boring a hole into the cross-head, and screwing in a piece of three-eighths round iron, the outer end of which is flattened and has an eye drilled through it, then dropping the tapering stud on the outer end of the pantograph into the eye whenever it is desired to use the pantograph.

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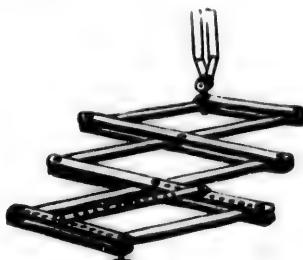


FIG. 19.

Fig. 19 shows the attachment in which the ways are horizontal; but we have not room enough to spread the pantograph out, as in Fig. 15 flat; but the pantograph in Fig. 19 is supposed to be vertical, as in the case where the post stands near the ways of the engine or the partition. In this case, the piece *D*, Fig. 16, is made use of; and the screw *C*, or the thumb nut, is attached to the bottom of *D*.



FIG. 20.

Fig. 20 shows the old-fashioned pendulum attached to a vertical guide or way. In this case, a little slot in the lower end of the pantograph is necessary. The links may not necessarily be used in the position shown, but may be brought up at right angles, leaving the slot to make allowance for the circle described.

This attachment avoids drilling, tapping, taking out the screws that confine the gib, or defacing the engine anywhere. On slow-moving or condensing engines, these attachments can be applied so that the pantograph can at any time be hooked on while running; and diagrams can be taken from the high or low pressure cylinder, from the pumps, stand-pipe, or anywhere that is necessary.

It is a simple little convenience ; and, as we have found within the past few months, it saves a great deal of vexation and delay, and insures more accuracy in the work, if only a little pains are taken. One point must also be observed by parties in using the pantograph ; that is, to allow a little leeway between the carrying-pulleys of the indicator and the cord peg of the pantograph : for we have seen some very awkward mistakes made by allowing the cord to sag a little, and to strike the screws in the ends of the short arms, which give a twitch to the indicator cord ; and we have been caught ourselves making saw-teeth on the expansion line of a card by this very apt-to-occur little matter.

Bacon's Attachment, patented July 25, 1882, is solely manufactured and for sale by the American Steam Gauge Company of Boston. It costs very little, and it is certainly a labor-saving and an annoyance-preventing device.

PRICE OF BACON'S PATENT ATTACHMENT FOR PAN-

TO TAKE A DIAGRAM.

Connecting-Cord.—The indicator should be connected to the engine cross-head by as short a length of cord as possible. Cord having very little stretch, such as accompanies the instrument, should be used; and, in cases of very long lengths, wire should be used.

The short piece of cord connected with the indicator is furnished with a hook; and at the end of the cord, connected with the engine, a running loop can be made, by means of the small plate sent with each instrument, in the manner shown in the accompanying cut; by which the cord can be adjusted to the proper length, and lengthened or shortened as required.



FIG. 21.

Selecting a Spring.—It is not advisable to use too light a spring for the pressure. Two inches are sufficient for the height of diagram, and the instrument will be less liable to damage if the proper spring is used. The gauge pressure divided by 2 will give the scale of spring to give a diagram two inches high at that pressure.

For rule to determine maximum pressure for each spring, and directions to change spring, see p. 9.

To attach a Card.—This may be done in a variety of ways, either by passing the ends of it under the spring clips, or by folding one end under the left clip, and bringing the other end around under the right; but, whatever method is applied, care should be taken to have the card rest smoothly and evenly on the paper drum.

Now attach the cord from the reducing-motion to the engine; but be certain the cord is of the proper length, so as to prevent paper drum from striking the inner stop in drum movement on either end of the stroke.

Tension of Drum Spring.—The tension of the drum spring should be adjusted according to the speed of the engine; increasing for quick running, and loosening for slower speeds.

The steam should not be allowed into the indicator until it has first been allowed to escape through the relief on side of cock, to see if it is clean and dry. If clean and dry, allow it into the indicator, and allow piston to play up and down freely.

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Before taking diagram, turn the handle of cock to a horizontal position, so as to shut off steam from piston, and apply pencil to the paper to take the atmospheric line.

In applying pencil to the card, always use the horn-handle screw, to regulate pressure of pencil upon paper to produce as fine a line as possible.

After the atmospheric line is taken, turn on steam, and press the pencil against card during one revolution.

When the load is varying, and the average horse-power required, it is better to allow the pencil to remain during a number of revolutions, and to take the mean effective pressure from the card.

Remove card after diagram has been taken; and on the back of card make note of the following particulars, as far as conveniently obtainable:—

18

DIAGRAM from M.....	Engine.....
Diameter of Cylinder.....	Built by.....
Length of Stroke.....	Pressure.....
Revolutions per Minute.....	Barometer reads.....
Pressure of Steam, in lbs., in Boiler.....	Throttle.....
Position of Throttle Valve.....	Regulator.....
Vacuum per Gauge, in inches.....	REMARKS.....
Temperature of Hot Well.....
Scale of Spring.....
Inside Diameter of Feed Pipe.....
" " " Exhaust Pipe.....
Valves.....

After sufficient number of diagrams have been taken, remove the piston, spring, etc., from the indicator, while it is still upon the cylinder; allow the steam to blow for a moment through the indicator cylinder; and then turn attention to the piston, spring, and all movable parts, which must be thoroughly wiped, oiled and cleaned. Particular attention should be paid to the springs, as their accuracy will be impaired if they are allowed to rust; and great care should be exercised that no grit or substance be introduced, to cut the cylinder, or scratch the piston.

Be careful always not to bend the steel bars or rods.

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The heat of the steam blown through the cylinder of the indicator will be found to have dried it perfectly, and the instrument may be put together with the assurance that it is all ready for use when required. Other items of precaution should be borne in mind (see p. 13).

Any engineer can easily repeat this operation without further instruction.

Diagram Analysis.

The following *definitions* have been given to the different parts of the diagram proper, and to lines added as required for purposes of analysis. The same letters refer to the same parts on different diagrams.

Figs. 22 and 23 are from throttling-engines; the former representing good performances for that class of engine, and the latter in some respects, which the engineer will readily recognize, bad performances.

Figs. 24, 25 and 26 are from automatics; Fig. 24 representing what is now considered rather too light a load for best practical economy, Fig. 25 about the best load, and Fig. 26 is from a condensing engine.

Line *AB* is the induction line, and *BC* the steam line; both together representing the whole time of admission.

C is about the point of cut-off, as nearly as can be determined by inspection. It is mostly anticipated by a partial fall of pressure due to the progressive closure of the valve.

The usual method is, to locate it about where the line changes its direction of curvature.

CD is the expansion curve.

D is the point of exhaust.

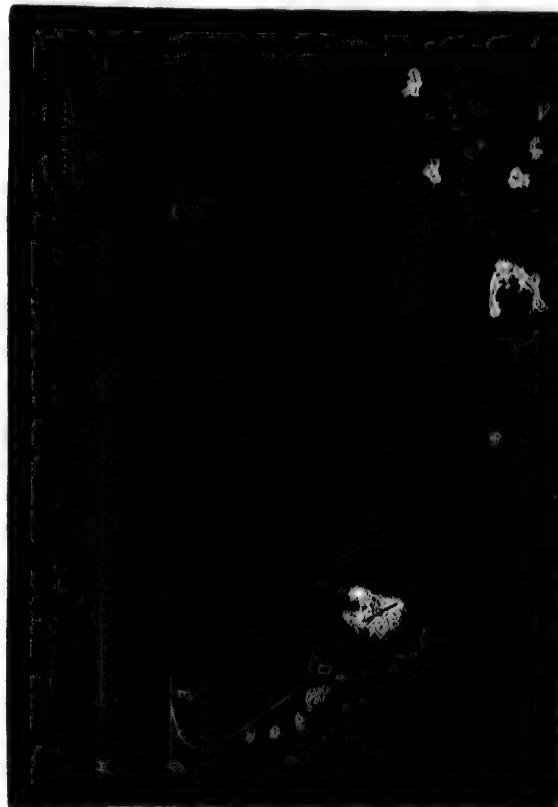
DE is the exhaust line, which should begin near the end of the stroke, and terminate at the end of the stroke, or, at least, before the piston has moved any considerable distance on its return stroke.

The principal defect of Fig. 23 is, that this line occupies nearly all of the return stroke. *EF* is the back pressure line, which in non-condensing engines should be coincident with, or but little above, atmospheric pressure. In Fig. 26 it is below the atmospheric line to the extent of the vacuum obtained in the cylinder. Some authorities would call it the vacuum line in Fig. 26, but that name properly belongs to a line representing a perfect vacuum.

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F is the point of exhaust closure (slightly anticipated by rise of pressure), and *PA* the compression curve, which, joining the admission line at *A*, completes the diagram proper, forming a closed figure.

GG is the atmospheric line traced when the piston of the indicator is subject to atmospheric pressure, above and below alike. Some



pull the cord by hand when tracing it, to make it longer than the diagram. *HH* is the vacuum line, which, when required, is located

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by measurement such a distance below the atmospheric line as to represent the atmospheric pressure at the time and place, as nearly

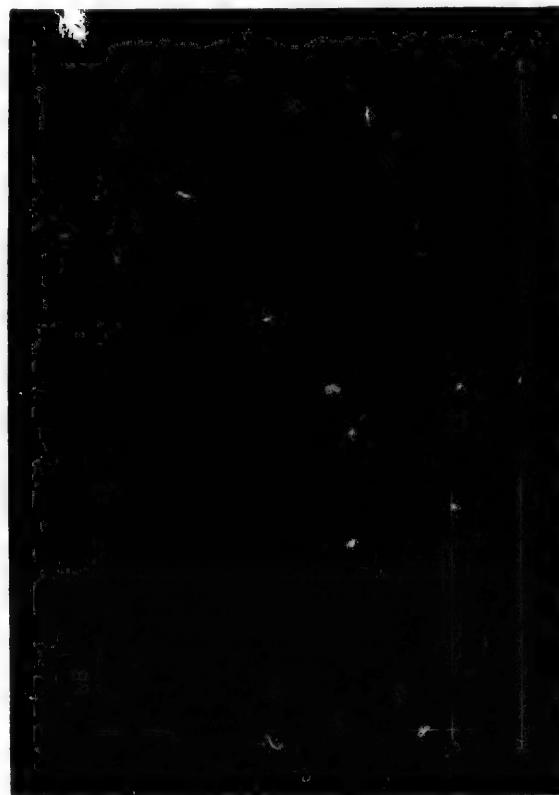


FIG. 23.

as can be ascertained. The mean atmospheric pressure at the sea level is 14.7 pounds. For higher altitudes, the corresponding mean pressure may be found by multiplying the altitude by .00053, and subtracting the product from 14.7. When a barometer can be consulted, its reading in inches multiplied by .49 will give the pressure in pounds.

I is the clearance line, representing, by its distance from the nearest point of the end of the diagram at the admission end, as

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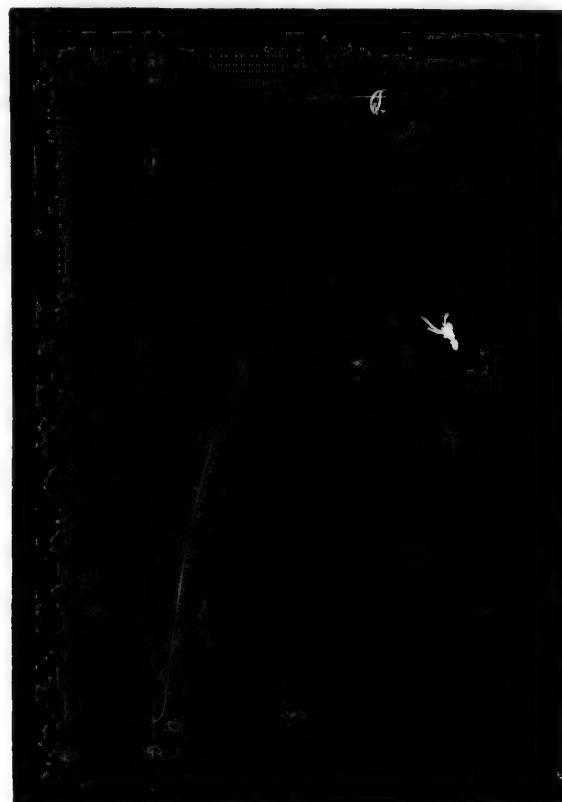
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compared with the whole length, the whole volume of clearance known to be present. Its use is mainly to assist in constructing a theoretical expansion curve by which to test the accuracy of the actual one.

Calculating Mean Effective Pressure.—Since the simplification and popularization of the planimeter, no engineer who has



occasion to compute the "indicated horse-power" (IHP) of engines should be without one: for, if properly handled, the results obtained by them are more accurate and more quickly obtained than by any other process.

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The diagram is pinned to a smooth board covered with a sheet of smooth paper, the pivot of the leg pressed into the board at a point which will allow the tracing-point to be moved around the outline of the diagram without forming unnecessarily extreme angles between the two legs, and a slight indentation made in the line at some point convenient for beginning and ending; for it is vitally important that the beginning and ending shall be at exactly the same point.

The reading of the wheel is taken, or it is placed at zero, and the

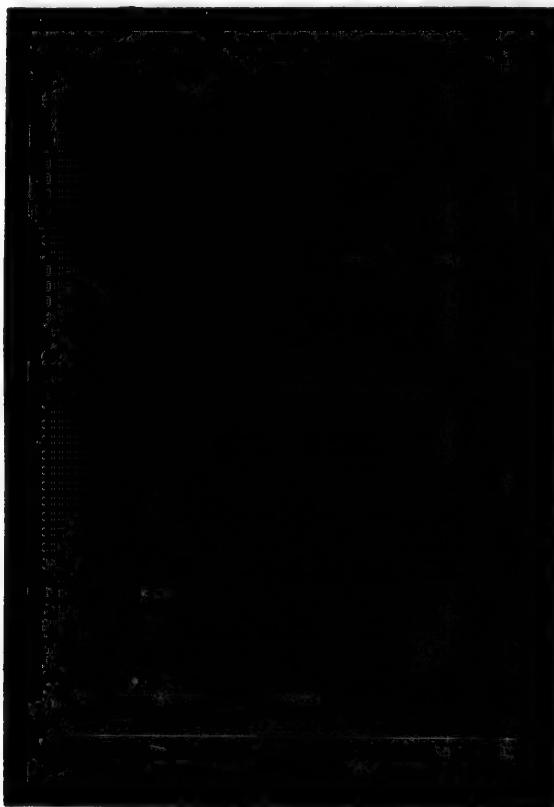


FIG. 25.

tracing-point is passed carefully around the diagram, following the lines as closely as possible, moving right-handed, like the hands of

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a watch. The reading obtained (by finding the difference between the two if the wheel has not been placed at zero) is the area of the diagram in square inches, which, multiplied by the scale of the diagram, and divided by its length in inches, gives the mean effective pressure.

The Process of finding the Mean Effective Pressure by Ordinates.—Fig. 25 is too well known to require any detailed explanation at our hands; but we wish to call attention to a frequent mis-

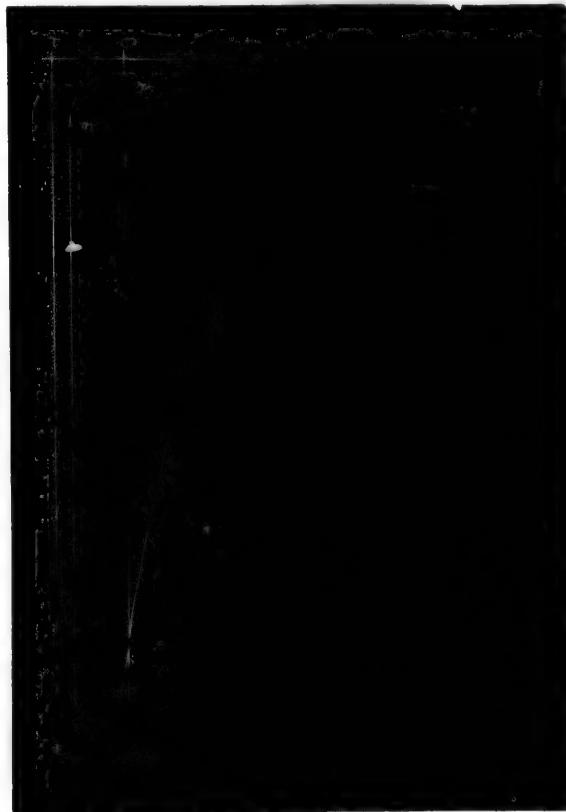


FIG. 26.

take, namely, making all the spaces equal. The end ones should be half the width of the others, since the ordinates stand for the centres of equal spaces.

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Ten is the most convenient and usual number of ordinates, though more would give more accurate results. The aggregate length of all the ordinates (most conveniently measured consecutively on a strip of paper) divided by their number, and multiplied by the scale of diagram, will give the mean effective pressure.

A quick way of making a close approximation to the mean effective pressure of a diagram is, to draw line ab , Fig. 27, touching at a , and so that space d will equal in area spaces c and e , taken together, as nearly as can be estimated by the eye.

Then a measure, f , taken at the middle, will be the mean effective pressure. With a little practice, verifying the results with the planimeter, the ability can soon be acquired to make estimates in this way with only a fraction of a pound of error with diagrams representing some degree of load. With very high initial pressure and early cut-off, it is not so available.

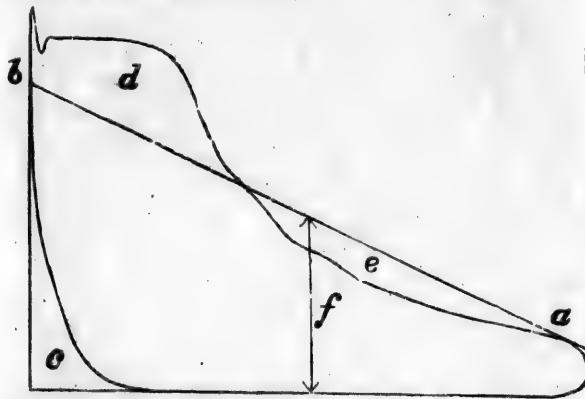


FIG. 27.

The Indicated Horse-Power. — IHP is found by multiplying together the area of the piston (minus half the area of the piston-rod section when great accuracy is desired), the mean effective pressure, and the travel of the piston in feet per minute, and dividing the product by 33,000.

It is sometimes convenient to know the HP *constant* of an engine which is its HP for one revolution at one pound mean effective pressure.

This multiplied by the mean effective pressure, and by its number of revolutions per minute, gives the IHP.

THEORETICAL CURVE.

Testing Expansion Curves. — It is customary to assume that steam, in expanding, is governed by what is known as Mariotte's law, according to which its volume and pressure are inversely proportional to each other. Thus, if 1 cubic foot of steam at, say, 100 pounds pressure be expanded to 2 cubic feet, its pressure will fall to 50 pounds, and proportionately for all other degrees of expansion. The pressures named are "total pressures;" that is, they are reckoned from a perfect vacuum.

A theoretic expansion curve which will conform to the above theory may be traced by the following method.

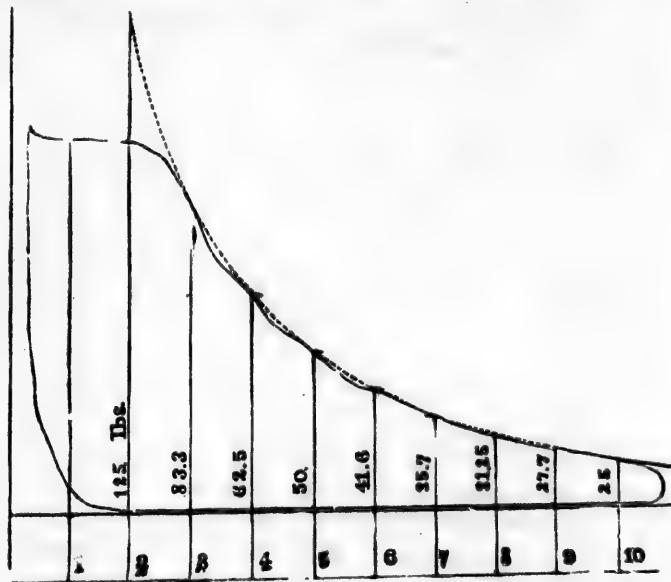


FIG. 28.

Referring to Fig. 28, having drawn the clearance and vacuum lines, as before explained, draw any convenient number of vertical lines, 1, 2, 3, 4, 5, etc., at equal distances apart, beginning with the clearance line, and number them as shown.

Decide at what point in the expansion curve of the diagram you wish the theoretic curve to coincide with it. Suppose you choose

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line 10, on which you find the indicated pressure to be 25 pounds. Multiply this pressure by the number of the line (10), and divide the product (250) by the numbers of each of the other lines in succession. The quotients will be the pressures to be set off on the lines. Thus, 250 divided by 9 gives 27.7, the pressure on line 9; and so for all the others.

The same curve may also be traced by several geometric methods, one of which is as follows, referring to Fig. 29:—

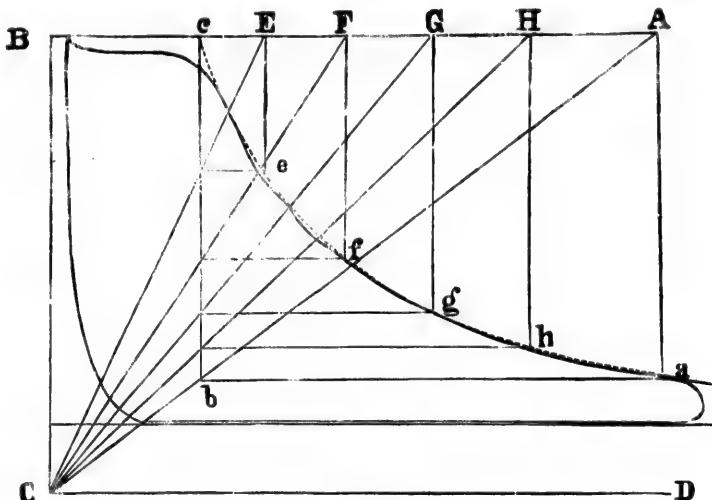


FIG. 29.

Having drawn the clearance and vacuum lines as before, select the desired point of coincidence, as α , from which draw the perpendicular αA . Draw AB at any convenient height above or near the top of the diagram, and parallel to the vacuum line DC . From A draw AC , and from α draw αb parallel to DC ; and from its intersection with AB erect the perpendicular bc , locating the theoretical point of cut-off on AB . From any convenient number of points in AB (which may be located without measurement), as E, F, G, H , draw lines to C , and also drop perpendiculars Ee, Ff, Gg, Hh , etc. From the intersection of EC with bc , draw a horizontal to e , and the same for each of the other lines FC, GC, HC ; establishing points e, f, g, h , in the desired curve. Any desired number of points may be found in the same way.

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But this curve does not correctly represent the expansion of steam. It would do so if the steam during expansion remained, or was maintained at a uniform temperature; hence it is called the *isothermal* curve, or curve of same temperature. But, in fact, steam and all other elastic fluids fall in temperature during expansion, and rise during compression: and this change of temperature augments the change of pressure slightly; so that, if, as before assumed, a cubic foot of steam at 100 pounds total pressure be expanded to two cubic feet, the temperature will fall from nearly 328° to about 278° , and the pressure, instead of falling to fifty pounds, will fall a trifle below 48 pounds.

A curve in which the pressure due to the combined effects of volume and resulting temperature is represented, is called the *adiabatic* curve, or curve of no transmission; since, if no heat is transmitted to or from the fluid during change of volume, its sensible temperature will change according to a fixed ratio, which will be the same for the same fluid in all cases.

We need not attempt to give any of the usual methods of tracing the adiabatic curve, since the isothermal curve is the one generally used for the purpose. And, while it is incorrect in that it does not show enough change of pressure for a given change of volume, the great majority of actual diagrams are still more incorrect in the same direction; so that, when a diagram conforms to it as closely as the one used in our illustrations, it is considered a remarkably good one.

A sufficiently close approximation to the adiabatic curve to enable the non-professional engineer to form an idea of the difference between the two, may be produced by the following process: —

Taking a similar diagram to that used for the foregoing illustrations, we fix on a point *A* near the terminal, where the total pressure is 25 pounds. As before, this point is chosen in order that the two curves may coincide at that point. Any other point might have been chosen for the point of coincidence; but a point in that vicinity is generally chosen, so that the result will show the amount of power that should be obtained from the existing terminal. This point is 3.3 inches from the clearance line, and the volume of 25 pounds is 996; that is, steam at that pressure has 996 times the bulk of water. Now, if we divide the distance of *A* from the clearance line by 996, and multiply the quotient by each of the volumes of the other press-

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ures indicated by similar lines, the products will be the respective lengths of the lines measured from the clearance line; the desired curve passing through their other ends. Thus, the quotient of the first or 25-pound-pressure line divided by 996 is .003313; this multiplied by 726, the volume of 35 pounds pressure, gives 2.4 the length of the 35-pound-pressure line; and so on for all the rest.

On applying either of the above theoretical curves to diagrams, it

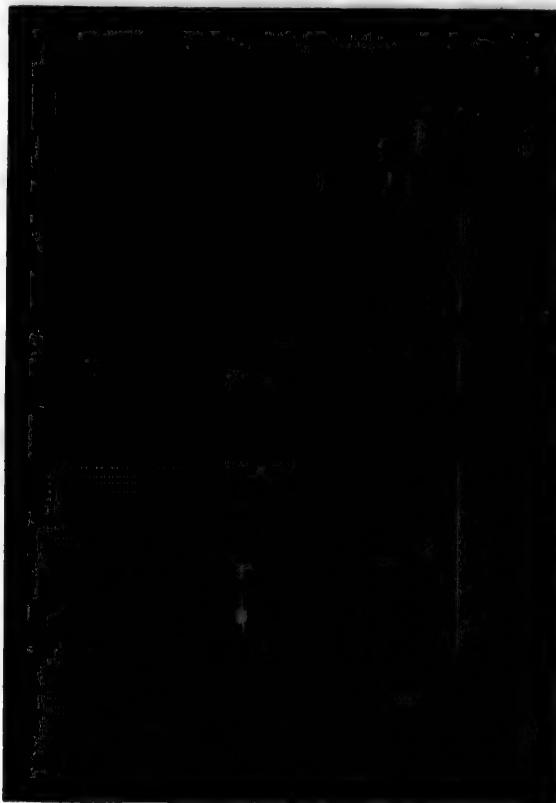


FIG. 30.

will be found that some are much more accurate than others, even amongst the same build of engine, embodying the same grade of workmanship. As a general rule, those from large engines will be more correct than from small ones, and high or tolerably high piston speeds than slow. Also, efficient covering for cylinders and steam-

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pipes to prevent radiation and condensation improves them in this respect.

The character of the imperfections revealed by this means is pretty uniformly the same; namely, too high a terminal pressure for the point of cut-off. The first part of the curve formed is generally the most correct, nearly all the inaccuracy making its appearance in the later half.

The generally accepted explanation is, that the incoming steam is partly condensed; but when the pressure is partly removed, and the expanded steam begins to be exposed to that part of the cylinder which has been recently heated by the steam which has just before acted on the other side of the piston, the water resulting from such condensation is re-evaporated into steam, which augments the terminal pressure, sometimes to the extent of five or more pounds. But valve leakage has, no doubt, often much to do with producing the fault, especially when it appears to any considerable degree in the case of engines of good size and speed, with well-protected cylinders.

Water-consumption Calculations. — An engine driven by water instead of steam, at a pressure of one pound per square inch, would require 859,375 pounds per HP per hour; the water being of such temperature and density that one cubic foot would weigh $62\frac{1}{2}$ pounds. If the mean pressure were more than one pound, the consumption would be proportionately less; and, if steam were used, the consumption would be as much less as the volume of steam used was greater than an equal weight of water. Hence, if we divide the number 859,375 by the mean effective pressure and by the volume of the terminal pressure, the result will be the theoretical rate of water consumption in pounds per IHP per hour.

For the terminal pressure, we may take the pressure at any convenient point in the expansion curve near the terminal, as at *A*, Fig. 30, in which case the result found must be diminished in the proportion that the portion of stroke remaining to be made, *ab*, bears to the whole length of the stroke *ab*; and it may also be diminished by the proportion of stroke remaining to be made after the pressure at *A* has been reached in the compression curve at *B*. In other words, *AB* is the portion of the stroke *ab* during which steam at the pressure at *A* is being consumed. Hence the result obtained by the above rule is multiplied by *AB*, and the product divided by *ab*.

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To illustrate, suppose the mean effective pressure of the diagram to be 37.6 pounds, and the pressure at *A* 25 pounds, of which the volume is 996. Then $\frac{859.375}{37.6 \times 996} = 22.94$ pounds water per IHP per hour, the rate that would be due to using an entire cylinder full of steam at 25 pounds pressure every stroke. But as the period of consumption is represented by *BA*, *ba* being the stroke, the following correction is required: $\frac{22.94 \times 3.03}{3.45} = 20.15$; 3.03 inches being the portion *BA*, and 3.45 inches being the whole length *ba*. This correction allows for the effects of clearance as well as compression, since, if more clearance had existed, the pressure at *A* would not have been reached till later in the stroke, and the consumption line *BA* would have been longer.

But such a rate can never be realized in practice. Under the best attainable conditions, such as about the load indicated on the diagram, or, more, on a large engine with steam-tight valves and piston, and well-protected cylinder and pipes, the unindicated loss will seldom be less than 10 per cent; and it will be increased by departure from any of the above conditions to almost any extent. It will increase at an accelerating ratio as the load is diminished, so that such calculations applied to light-load diagrams would be deceptive and misleading; in fact, they have but little practical value except when made for comparison with tests of actual consumption, for the purpose of determining the amount of loss under given conditions.

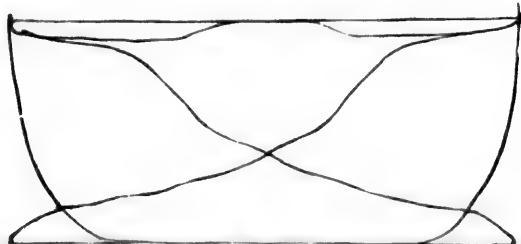


FIG. 31.

Pipe Diagrams. — Sometimes when considerable loss of pressure appears on comparing that shown by the gauge with the highest initial pressure shown by the diagram, it will be found very instruc-

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tive to connect the indicator with the steam pipe in addition to its usual connections. A $\frac{1}{4}$ inch or $\frac{3}{8}$ inch pipe will be sufficient for the purpose, with a valve or cock as close to the indicator as convenient. Before or after taking the cylinder diagrams steam is admitted to the instrument from the steam pipe and the pencil applied, when a diagram similar to that shown above the cylinder diagrams in Fig. 31 is produced. In that figure it shows that there is scarcely any loss of pressure between the pipe and the piston, all the loss being in the pipe at the beginning of the stroke, though a little loss of pressure between the pipe and piston appears as the point of cut off is approached.

Sometimes,—frequently, in fact,—the pressure in the pipe rises above that in the boiler for a moment after cut off, but such extra pressure will be readily recognized by its falling again before the next admission. This is due to the momentum of the steam when suddenly cut off, and its effects will be greatest with long, straight pipes.

When the pipe diagram is above and clear of the cylinder diagrams at all points, the space separating them is the measure of the loss of pressure due to passing through the cylinder ports and all passages between the point from which it is taken and the piston, while the variations of pressure in the pipe diagram indicate the loss due to passing through the pipe, allowance being made, as above explained, for the rebound of pressure above that in the boiler, when it is shown to exist.

NOTICE.

We shall be pleased to furnish electrotypes of the Thompson Improved Indicator, or any other instrument illustrated in this catalogue to parties desiring them to use in other catalogues.

American Steam Gauge Co., Boston.

AMSLER'S POLAR PLANIMETER.

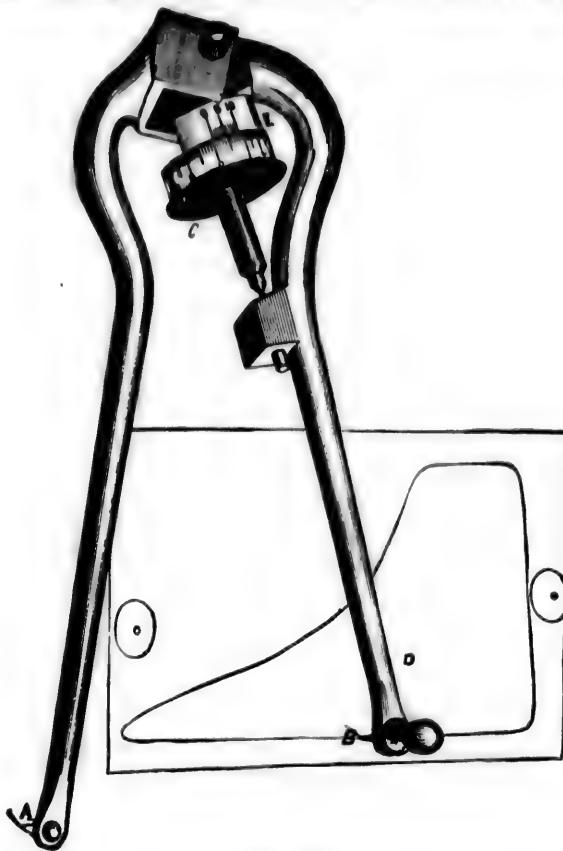


FIG. 32.

There are several other instruments which are used as accessories to the indicator, and which greatly facilitate the using of the instrument, one of which is Amsler's Polar Planimeter, as shown by the accompanying cut, for measuring the area of indicator diagrams. By using this instrument, the whole work of measuring a diagram can be done in one minute.

Engineers who have many indicator cards to work up cannot afford to be without a planimeter.

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Directions for Using the Instrument.

Press the point *A* slightly into the paper, not clear through, in such position that the tracer *B* will follow the desired line without bringing the roller *C* against any projection. The roller must move on a continuous flat surface.

It is also well to fasten the diagram to a drawing-board, or some other flat surface, by means of pins or springs, to prevent it from slipping.

Mark a starting-point at any point on the outline of diagram *D*, set the tracer on that point, and place zero on the roller so it exactly coincides with the zero on vernier *E*.

Now trace the line, moving in the direction travelled by the hands of a watch; stop at the starting-point, and take the reading.

1st. Find the highest figure on the roller that has passed the zero on the vernier, moving to the left, which we will assume to be 4; now the construction of the instrument is such that each figure on the roller represents an equal number of square inches.

2d. Find the number of *completed* divisions between 4 on the roller and zero on the vernier, which we will assume to be 5.

3d. Find the number of the mark on the vernier which coincides with some mark on the roller, which, in this case, may be 6.

We now have the exact reading, 4.56 or $4\frac{56}{100}$ inches area.

In measuring diagrams of more than 10 inches area, add 10 to the result.

To those who are perfectly familiar with the instrument, it is not necessary to place the zeros so they coincide; but take the reading as it is, and subtract it from the result. Should the second reading be less than the first, add 10 to the second reading before making the subtraction.

For instance, should the first reading be 8.42, and the second reading 2.68, add 10 to the second reading, thus: $2.68 + 10 = 12.68 - 8.42 = 4.26$ square inches.

If the area to be measured be very large, divide it by lines into areas of less than 20 square inches, and take separate measurements.

If the drawing be to a scale, multiply the result by the square of the ratio number of the scale.

Should we desire to find the area of a plan containing 5 square inches, drawn to a scale of 100 rods to the inch, we square the ratio

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number, and multiply by 5, thus: $100 \times 100 = 10,000 \times 5 = 50,000$ square rods.

In using the planimeter for indicator diagrams, for which it is *specially* adapted, we find the area of the diagram according to the foregoing directions, which we will assume to be 2.48; we now measure the length of the diagram parallel with the atmospheric line, which we will say in this case is 4 inches. Now divide the area by the length; the quotient is the mean or average height of the diagram in inches, which is .62 inch. This we multiply by the scale of the indicator, which we will assume to be 40; the product gives us 24.8 pounds mean pressure each square inch of the piston.

Expressed arithmetically, $2.48 \div 4 = .62 \times 40 = 24.8$.

It can also be used for measuring any regular or irregular plot or diagram.

The following is from "The American Machinist" of Dec. 27, 1879, by Chordal:—

THE POLAR PLANIMETER.—This little instrument, of which the cut is about three-fourths size, is used as the cut shows. The point *A* is stationary, and the tracer *B* is moved once over the outline of the diagram. The reading of the index wheel *C* then shows the area of the diagram in square inches. This reading divided by the length of the diagram, and multiplied by the scale of the spring, gives mean pressure of the card. The demonstration of the action of this simple instrument would require too much space, and I will defer it. The instrument will stand any possible test for accuracy, and eliminates all those ever-present chances for error involved in the human measurement of many ordinates. The time required to ascertain the mean pressure of the most ragged diagram need not exceed, when the planimeter is used, one minute. This instrument is one of the indispensables to an engineer having many cards to work up, and is a real labor-saver. The planimeter is the invention of Professor Amsler, a German, and, as made in Europe, was intended for comprehensive utility in measuring areas, and for giving results in sundry units, such as inches, feet, acres, and the long list of foreign superficial units. This involved considerable complexity in the instrument, and, of course, a high cost. Few in this country ever heard of them, and but two or three steam-engineers possessed them. The foreign makers sent horrible translations of the directions for use with the instruments. Among other things, this translation stated, that, 'as the principle of the instrument is a secret, there is no danger of others being put on the market.' This clause was the cause of the instrument being made in this country. It was a dare. Mr. James W. See, an engineer in Ohio, took the thing up, got at the principle, redesigned the instrument so as to make it specially useful for such work as indicator cards, and had quite a number made, which he sold and presented to engineers. They are now made by the American Steam Gauge Company of Boston, and, I am informed, are sold with nearly all indicators. A similar form of the instrument is made by Elliott Brothers, London; but it lacks the simplicity of the American one."

American Steam Gauge Co., Boston.

The planimeter is furnished in a nice morocco box, lined with velvet, and can be sent by mail to any place in the United States for nine cents.

The enormous sale we are having of this instrument shows how fully it is appreciated, we being the sole manufacturers in the United States.

Amsler's Polar Planimeter was awarded a silver medal and a diploma at the Cincinnati Industrial Exposition, Oct. 8, 1881.

After the second official trial of the new U.S. cruiser Baltimore, which took place in November, 1889, the computations of these diagrams were to be made with the planimeter instead of by the old fashioned methods. The diagrams from the second trial were to be computed first by the U.S. navy officers and afterwards by Mr. Thomas Pray, Jr., of Boston, for the builders of the ship, the Wm. Cramp & Sons Ship and Engine Building Co. During the computation by the navy officers, some questions arose which resulted in their pronouncing the planimeter made by this company incorrect. We publish here, by permission of Mr. Pray, a copy of his solution of the question at that time; also, his own comments on the subject, which were furnished by him, on request.

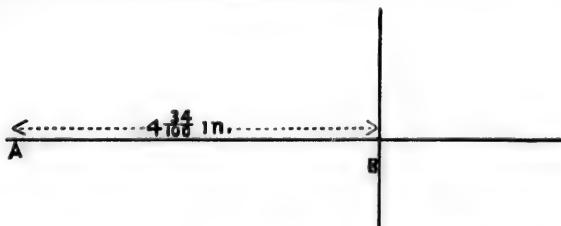
"The decision with reference to the planimeter is only another evidence that capable men sometimes disagree, and that men who mean to do exactly right sometimes make mistakes. This pow-wow about the planimeter, as applied to the diagrams of the Baltimore is of a great deal more importance than the average man supposes.

"When it is taken into account that on the engines of this ship one pound of mean pressure on one single engine is worth \$30,000, it is evident that correct computation of the cards ceases to be an amusement and becomes a veritable fact.

"I have, therefore, taken a personal interest of no small amount in demonstrating to my own satisfaction that your planimeter was either right or wrong, without any ifs, buts or ands. Here is a little solution that I give you my permission to print, only stipulating that you shall give me credit for it. It is this: if the planimeter is not correctly used it is incorrect in its results to a very small extent. If correctly used, I have found, in the work with reference to the U.S. cruiser Baltimore, which I am now doing in Philadelphia for the Wm. Cramp & Sons S. and E. B. Co., that these errors are larger in the person than in the instrument; that the instrument is capable of measuring an indicator diagram nearer correct than the person is of traversing the same line the second or third or any other number of times, and covering absolutely the same area.

American Steam Gauge Co., Boston.

"This makes the actual error of the instrument, by careful running, less than 1 in 1700. Here is the way to get correct results :—



"Take any piece of cardboard, Bristol board or strong paper, draw on it the line as in the figure A, any length you please, preferably about 8 inches long, at right angles to the line A, draw the line B, which may be any length you please, wider than the total width of the paper on which an indicator diagram is taken, but the line B must be drawn at exactly 4 3/4 inches from the point on line A where the other line intersects the long one, or, in other words, the distance between A and B must be as nearly 4 5/16 inches as can be laid down by an ordinary rule. Then put the point of the planimeter at A and put the card to be computed so that half the height shall be above and half below the line A, and half the length to the right and half to the left of the line B. Then if the reading pointer of the planimeter is correctly manipulated, the exact area of the figure will, in every case, be obtained, so long as proper care is exercised in reading.

"This will allow the use of high pressure, condensing, compound, locomotive, air pump or any other kind of card to be computed; and if the lines are drawn in ink and the distance is carefully measured and the planimeter properly managed, they will be found far nearer correct than the power of the person using them to repeat his own measurements absolutely. This was the result among the naval engineers, after the use of a large Amsler's planimeter, obtained from the navy department, and the actual difference in measurement of the same diagram between their and my own large Amsler was 1 in 2400, and the difference between my own large Amsler and my American Steam Gauge Amsler, No. 231, which I have used for several years, and three other American Steam Gauge Amslers, loaned for the purpose, was a little less than 1 in 1800 for the whole four; but by distorting the position of the instrument with reference to the figure, without the use of the simple diagram enclosed herewith, the errors of the little Amslers were as high as 1 in 560, and this error immediately vanished when the position of the same instrument was corrected by the two black lines drawn on a piece of drawing paper, the same as is referred to in the figure above.

"It is not necessary that the diagram should be placed perfectly parallel with the line A, but it may be placed at any angle to either line, so long as the centre of the area to be measured is kept over the intersection of the lines A and B. This is particularly the case whenever the diagrams are taken 4 3/4 or 5 inches long: or the diagram may be inverted and the vacuum line or the atmospheric line be nearest the instrument, or above the line A instead of below it.

"You have my permission to make use of this, by credit, in any way you see fit which is for your advantage and for the benefit of the thousands of men who are using your instruments."

American Steam Gauge Co., Boston.

TESTIMONIALS.

[COPY.]

NAVY DEPARTMENT, BUREAU OF STEAM-ENGINEERING,
WASHINGTON, April 7, 1879.

Sir. — In obedience to your order of the 5th inst., we have carefully examined the Polar Planimeter, submitted by H. K. Moore, and find it to be identical in design with Amsler's improvement on the original instrument of Appenhofer, but unprovided with attachments for changing the scale, or for recording the revolutions of the index roller.

The instrument submitted is light, neatly and well made, and all its working parts accurately fitted, and capable of delicate adjustment.

It can be readily manipulated by any person of ordinary intelligence; and, in our opinion, its use will greatly facilitate the work of measuring the areas of irregular figures, and will be particularly valuable to the Bureau for determining the mean pressure of indicator diagrams.

Very respectfully your obedient servants,

H. W. FITCH, *Chief Engineer, U.S.N.*
DAVID SMITH, *Chief Engineer, U.S.N.*
H. WEBSTER, *P.A. Engineer, U.S.N.*

TO ENGINEER-IN-CHIEF WM. H. SHOCK, U.S.N.,
Chief of Bureau Steam-Engineering, Washington, D. C.

[COPY.]

OFFICE OF JOHN W. HILL, MECHANICAL ENGINEER,
CINCINNATI, O., Dec. 29, 1879.

H. K. MOORE, Esq., *Boston, Mass.*

Dear Sir. — Upon my return from St. Louis, last week, I found your kind remembrance of the writer in the shape of a new planimeter, for which you have my sincere thanks.

I have carefully tested the instrument, and it varies but $\frac{1}{25000}$ in the circuit.

Very sincerely yours,

JOHN W. HILL.

. . . By its use, diagrams may be carefully and *correctly* measured in one minute, everything being taken into account, and the actual area found.

THOMAS PRAY, JR.

**PRICE OF THE PLANIMETER, ALL NICKEL-PLATED, AND
IN A VELVET-LINED BOX . . . \$15.00**

American Steam Gauge Co., Boston.

RICHARDS PARALLEL-MOTION
INDICATOR.

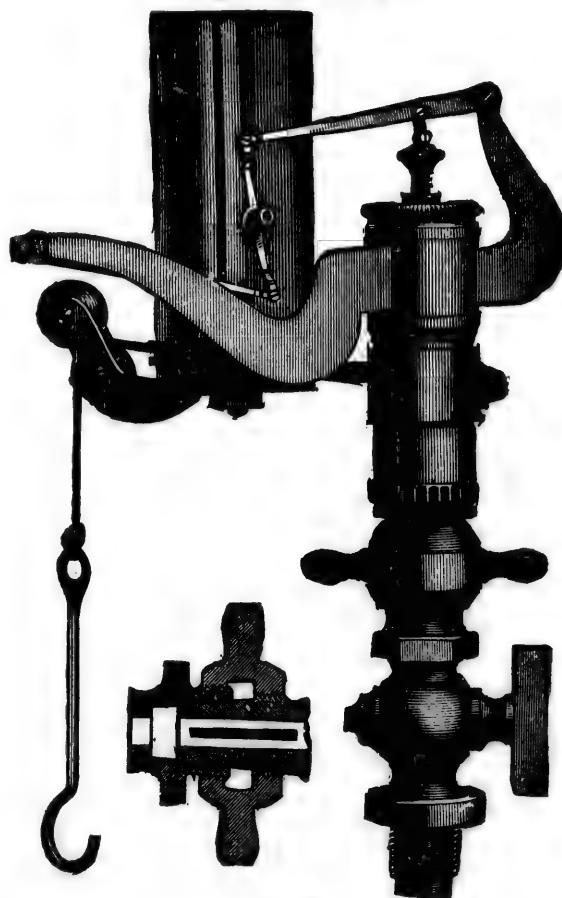


FIG. 33.

This indicator has been long and well known with the engineering public. It is not adapted for high-speed engines, but is perfectly reliable and accurate for engines making less than eighty revolutions per minute.

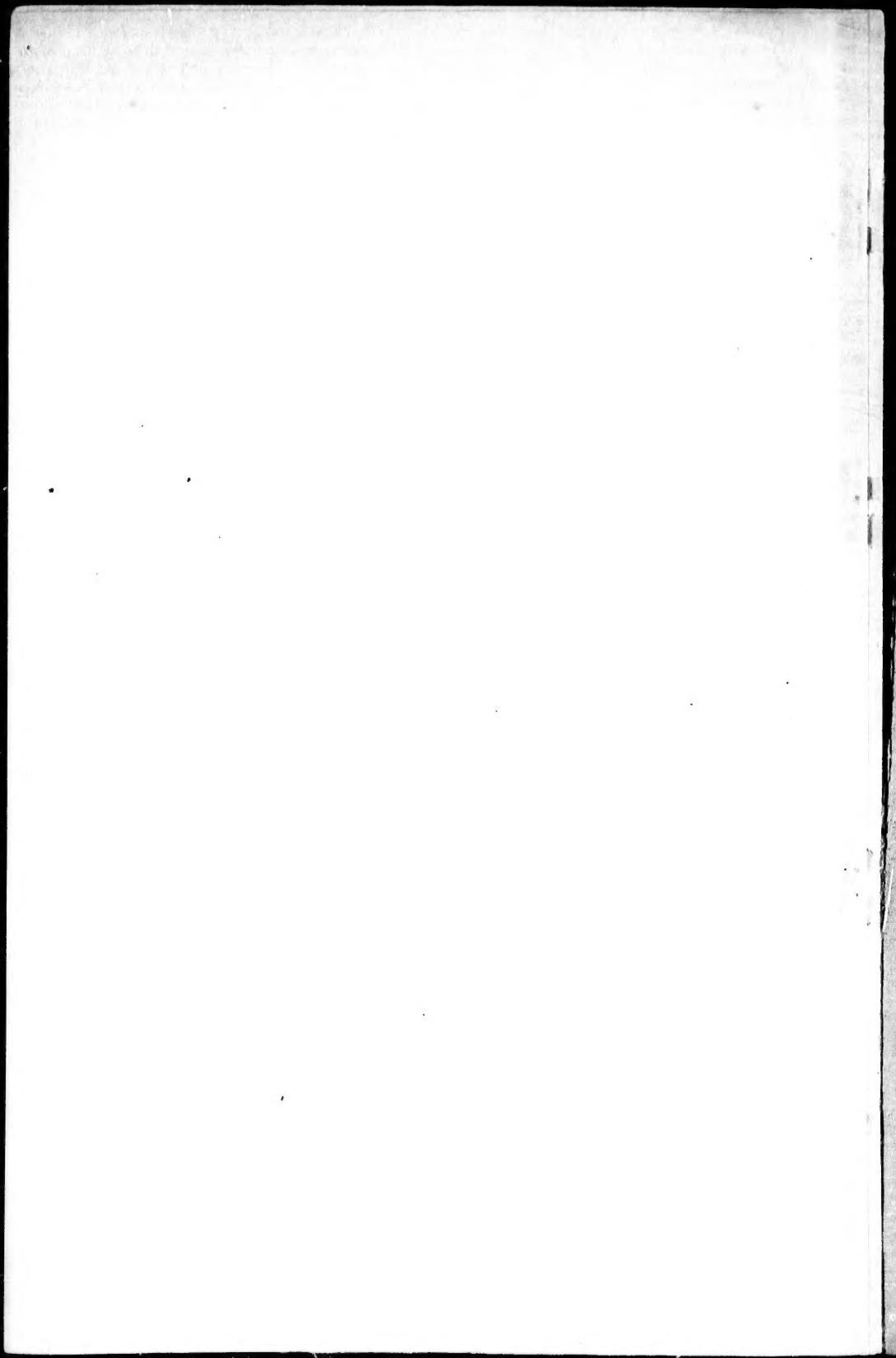
PRICE, \$85.00

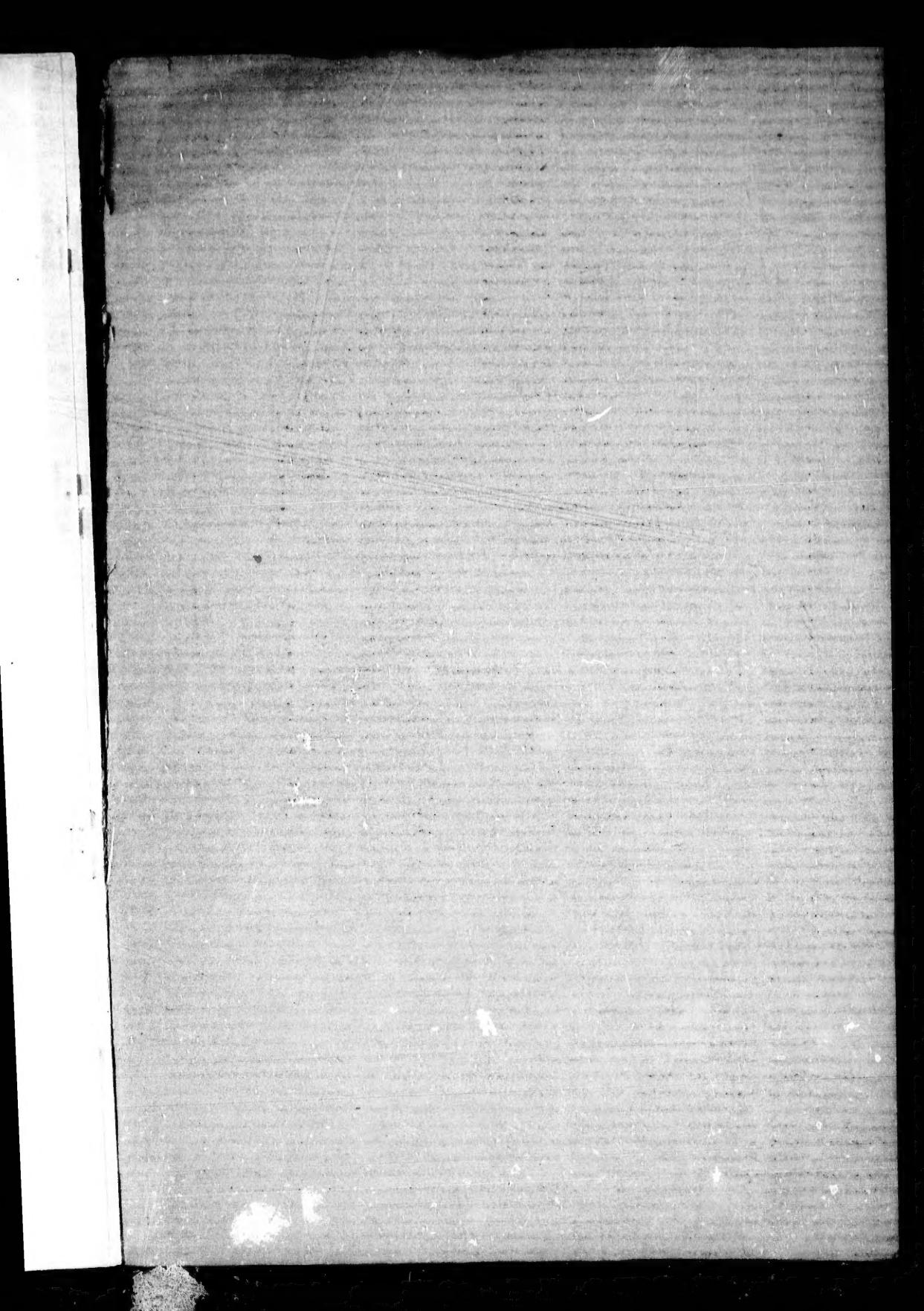
Extra springs, scales, cocks, elbows, etc., same price as those used with the Thompson Indicator.

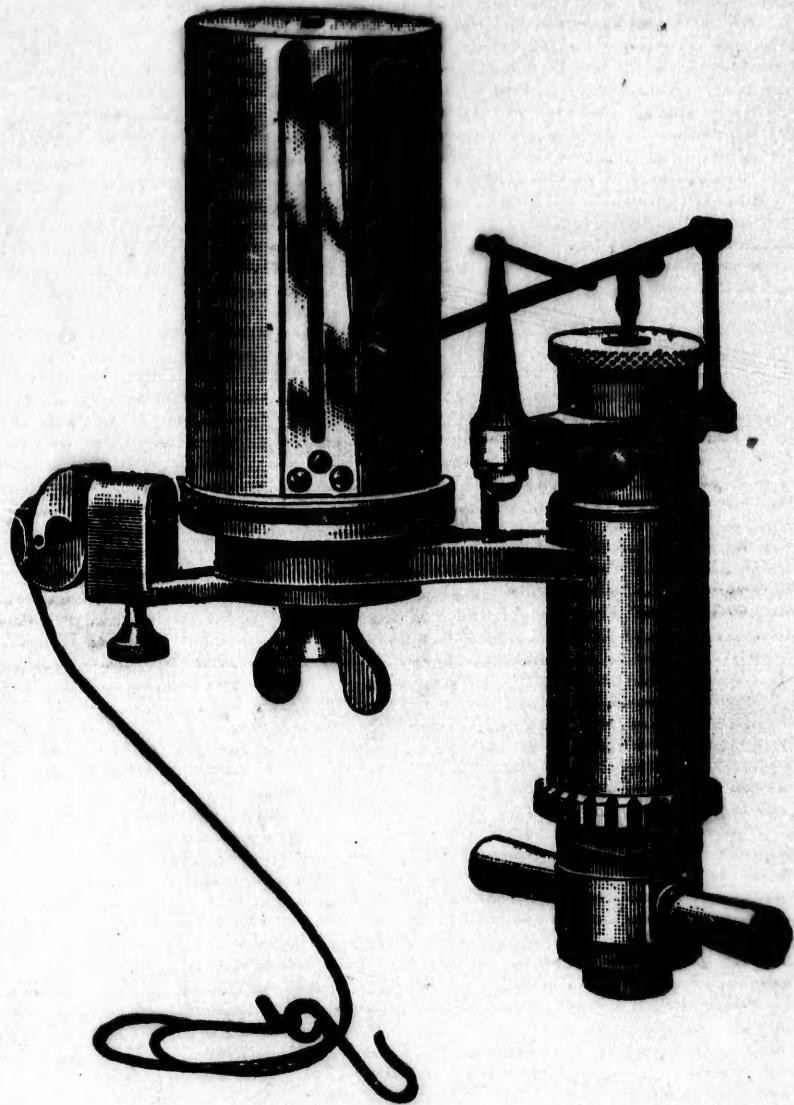
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THOMPSON IMPROVED INDICATOR.